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# United States Patent [19] Choi

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[54] **METHOD FOR FABRICATING A CAPACITOR OF A SEMICONDUCTOR DEVICE**

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[21] Appl. No.: **08/925,060**

[22] Filed: **Sep. 9, 1997**

### Related U.S. Application Data

[62] Division of application No. 08/670,592, Jun. 26, 1996, Pat. No. 5,702,970.

### [30] Foreign Application Priority Data

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Jun. 30, 1995	[KR]	Rep. of Korea	95-18911
Jun. 30, 1995	[KR]	Rep. of Korea	95-18912

[51] Int. Cl.<sup>6</sup> ..... **H01L 21/8242**

[52] U.S. Cl. .... **438/3; 438/240**

[58] Field of Search ..... 438/3, 240, 238, 438/239, 253, 254, 396, 397

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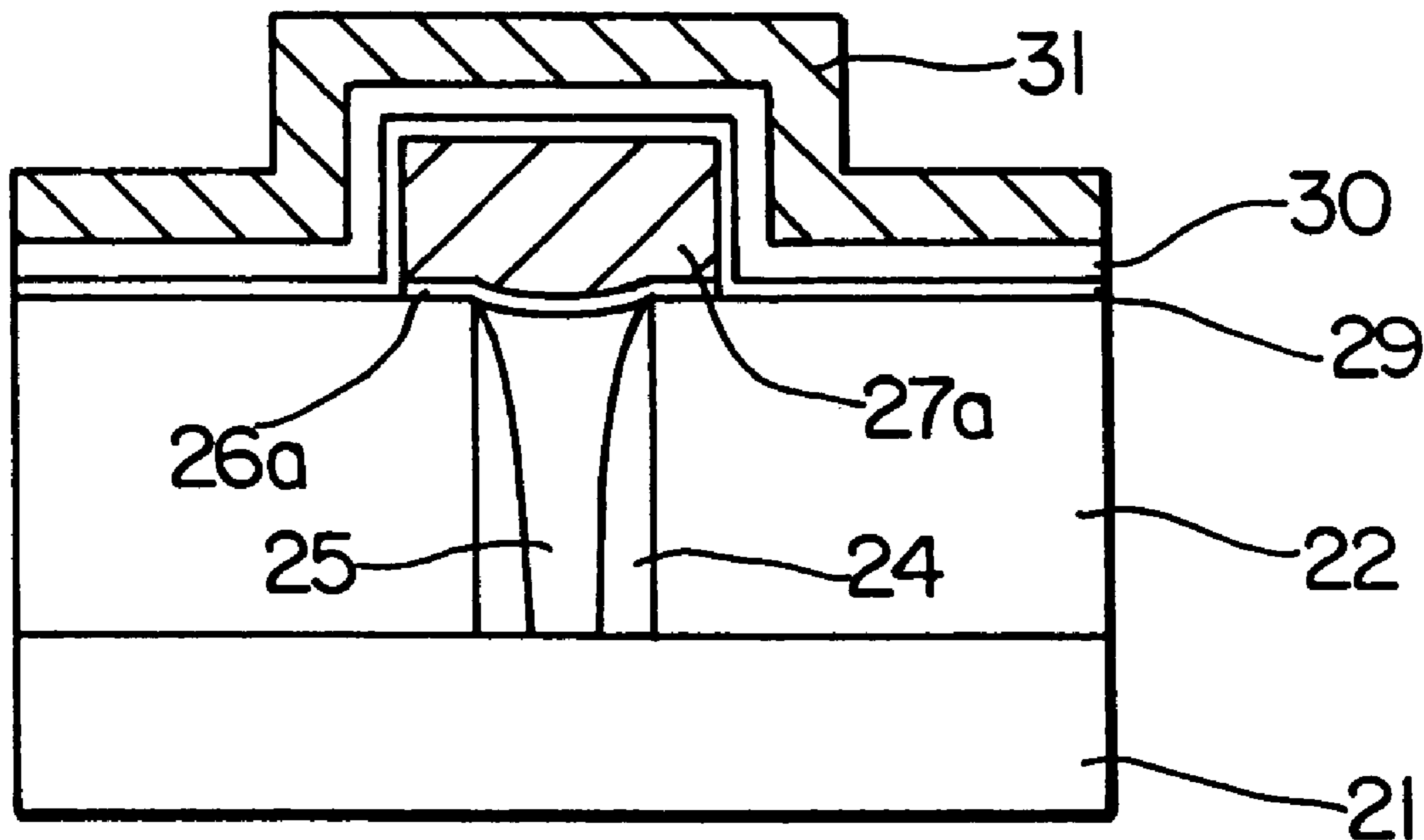
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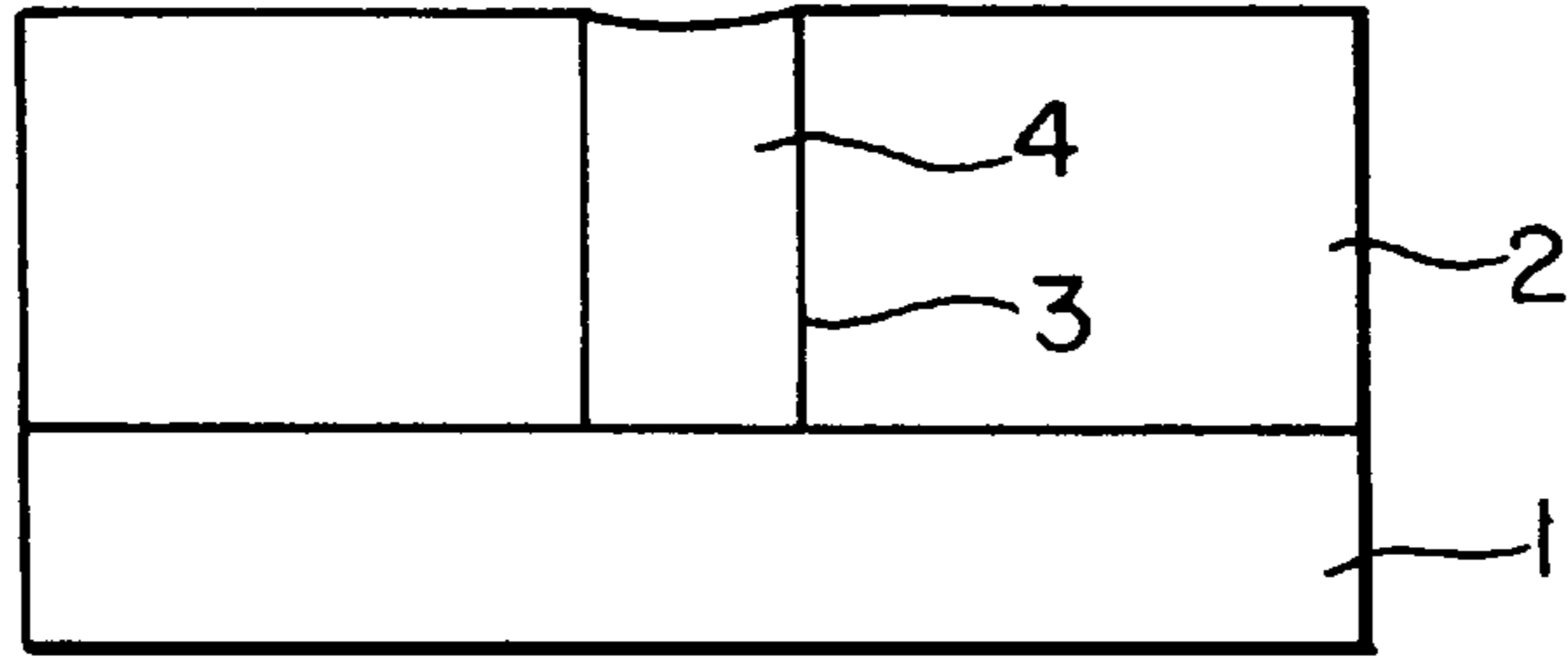
Primary Examiner—Joni Chang  
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### [57] ABSTRACT

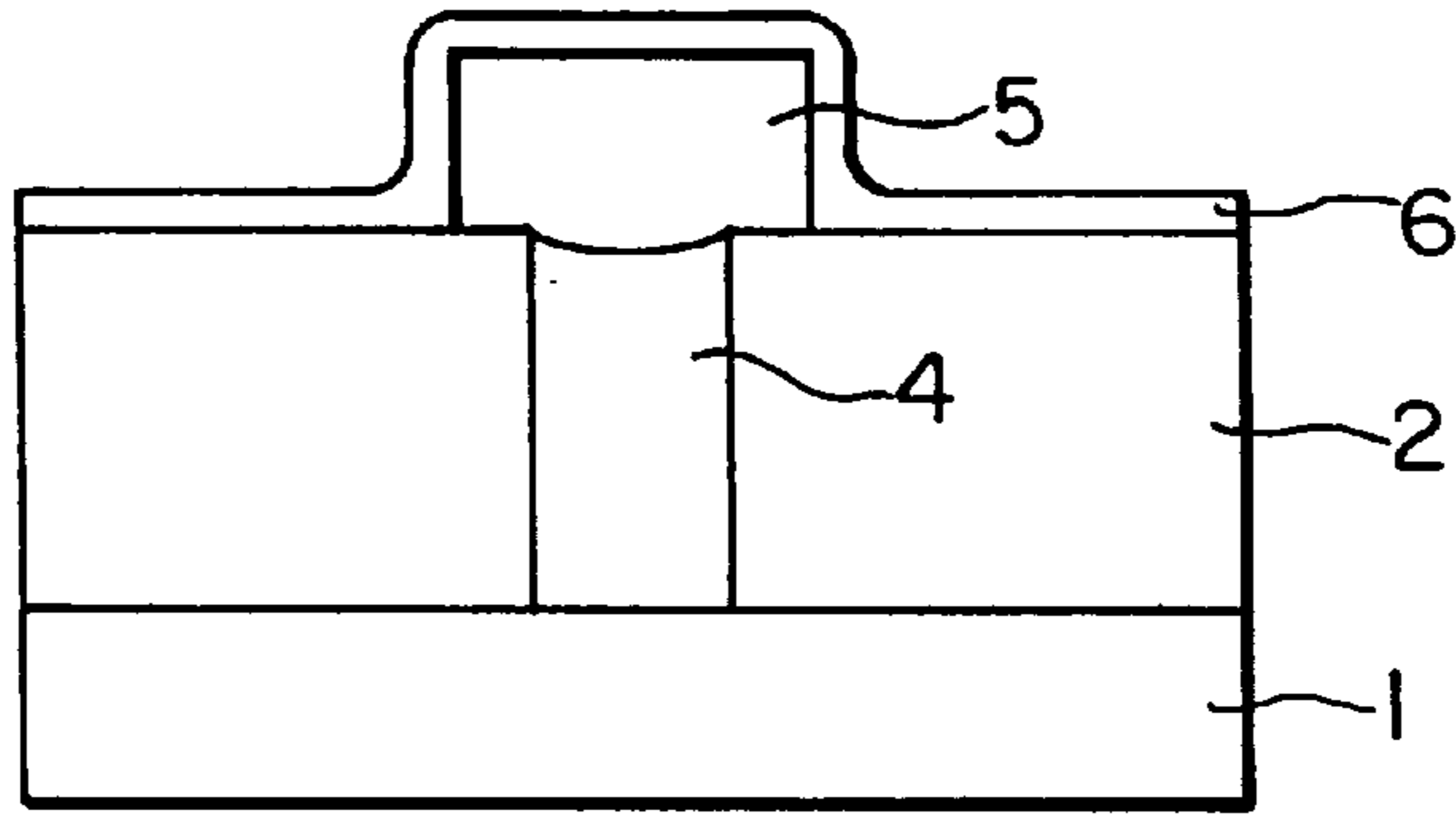
A method for fabricating a capacitor of a semiconductor device which stabilizes the operation of electrodes of the capacitor and improves the operational characteristic and reliability of the semiconductor device. The method comprises the steps of: preparing a semiconductor substrate; forming an insulating layer on the substrate; forming a contact hole by selectively eliminating the lower insulating layer; forming a plug in the contact hole; forming a Ti/TiN film thereon; forming a first ruthenium oxide film on the Ti/TiN film; forming a first SOG film on the first ruthenium oxide film; implanting impurities into a surface of the first SOG film; forming a second SOG film on the first SOG film, and then selectively eliminating the first and the second SOG films; etching the first ruthenium oxide film and the Ti/TiN film by utilizing the first and second SOG films as a mask; eliminating the first and second SOG films, and then forming a dielectric film on the exposed surface thereof; and forming a second ruthenium oxide film on the dielectric film.

6 Claims, 7 Drawing Sheets

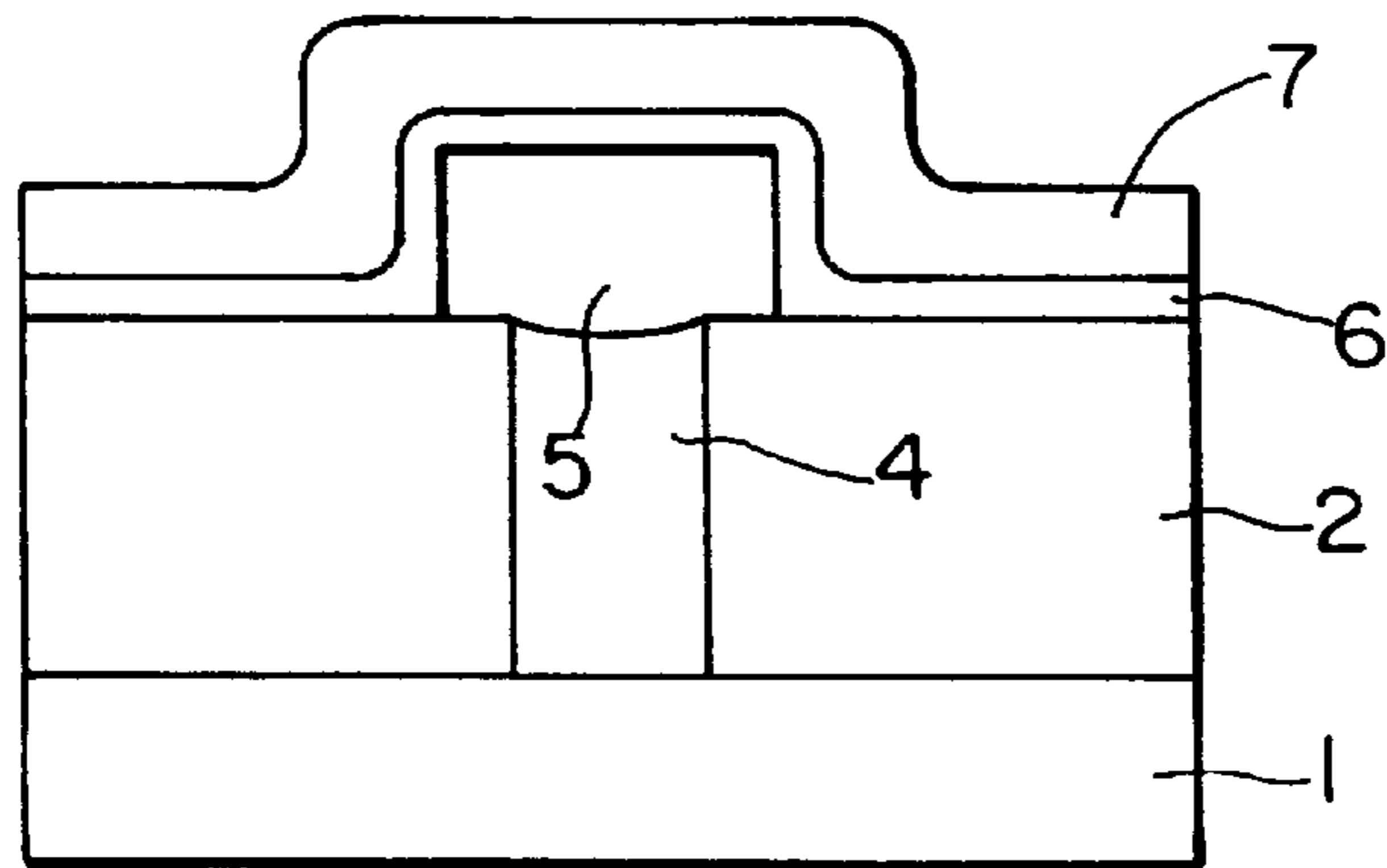




*FIG. 1A*  
(PRIOR ART)



*FIG. 1B*  
(PRIOR ART)



*FIG. 1C*  
(PRIOR ART)

FIG. 2A

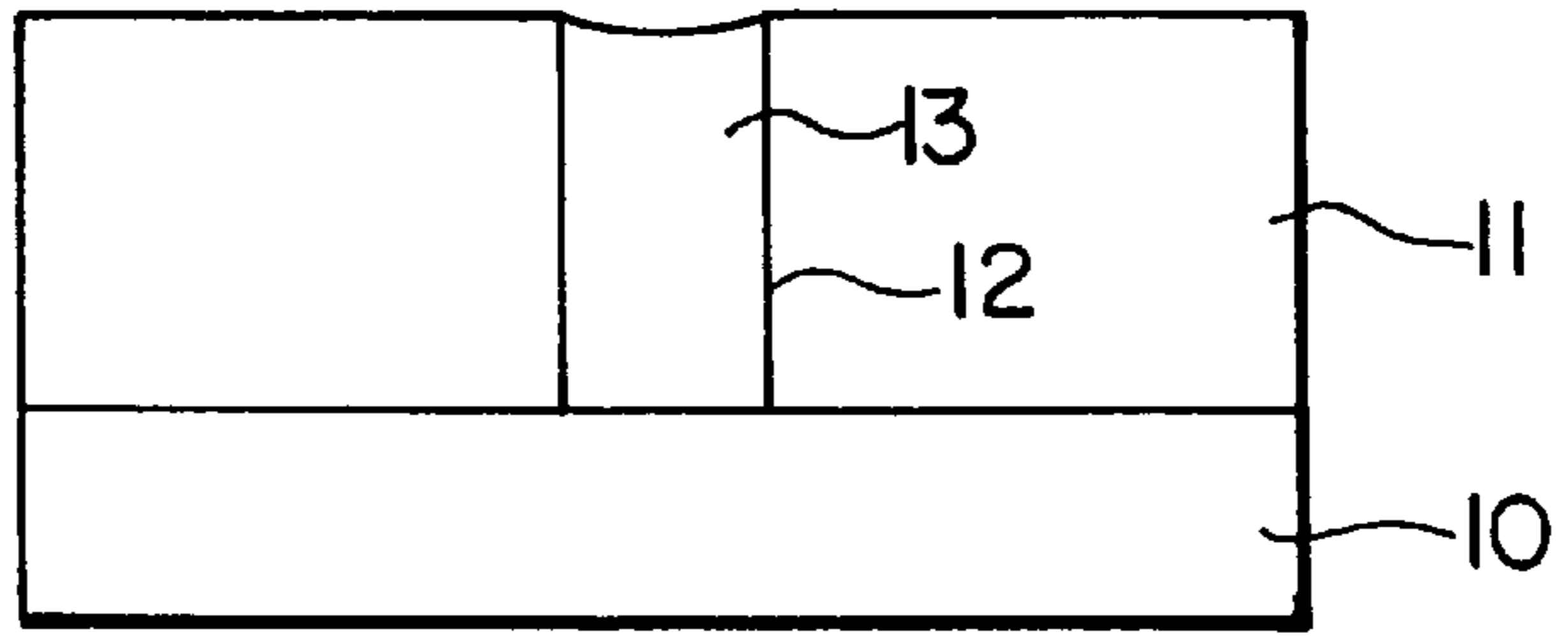


FIG. 2B

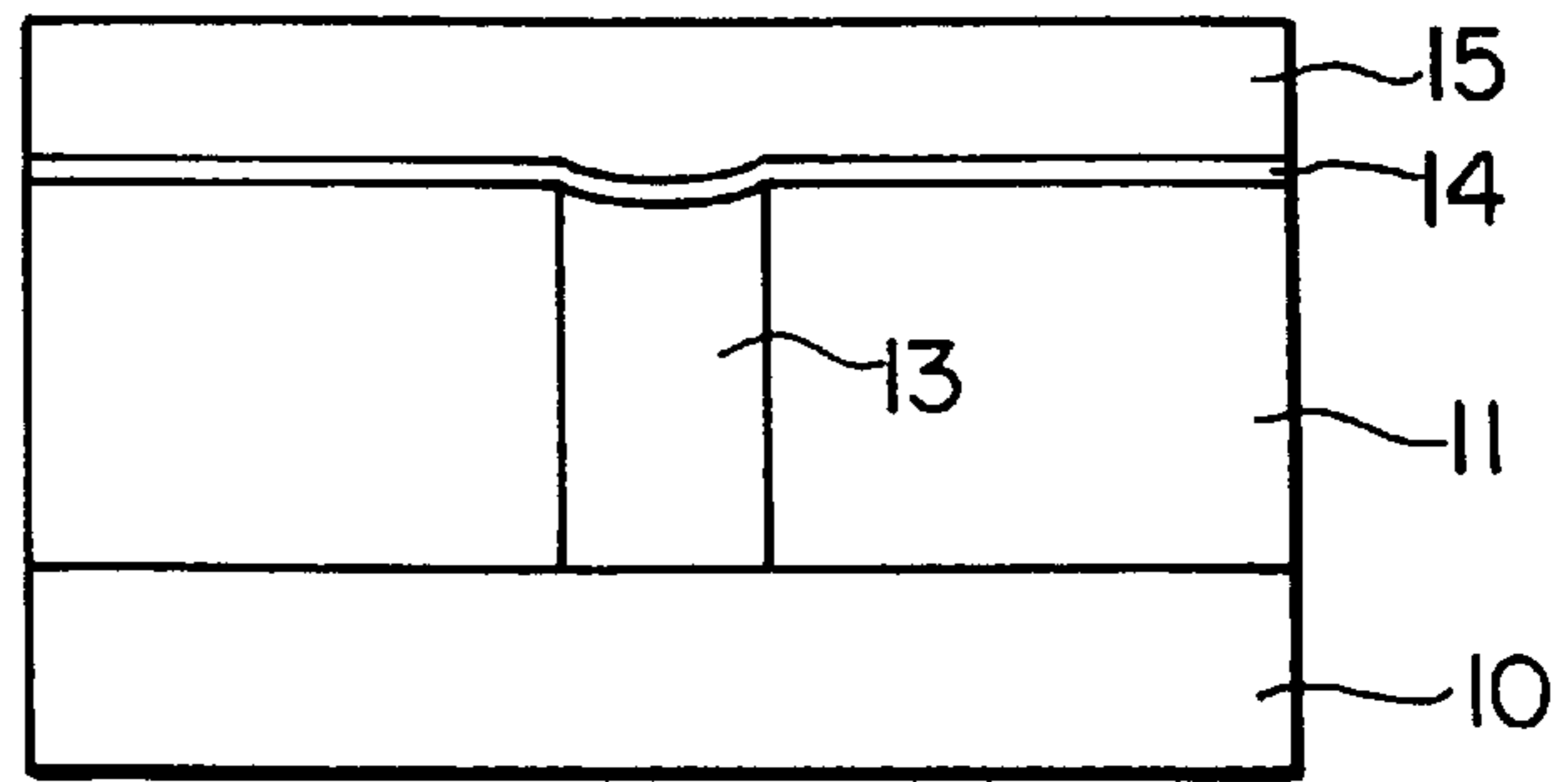


FIG. 2C

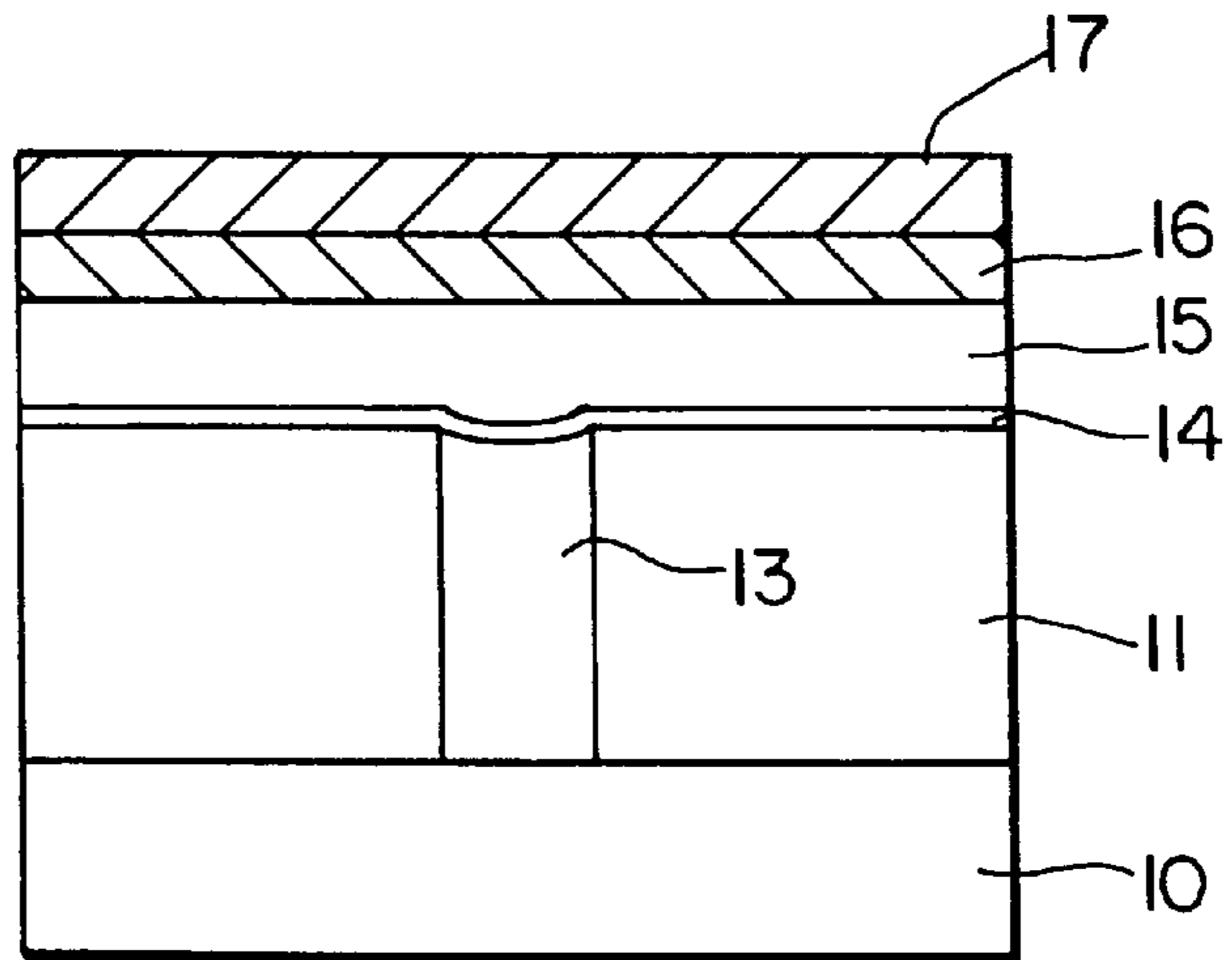


FIG. 2D

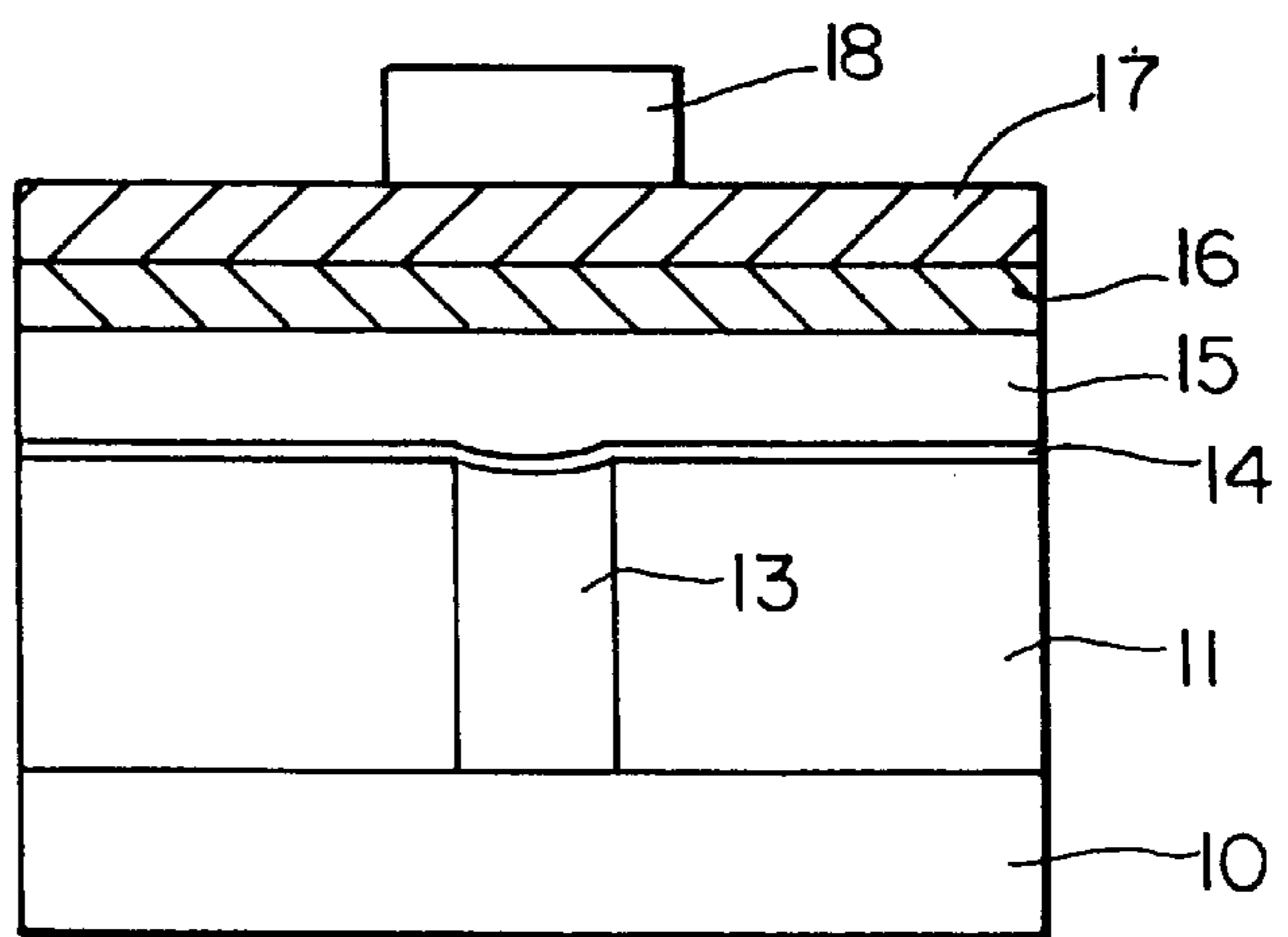


FIG. 2E

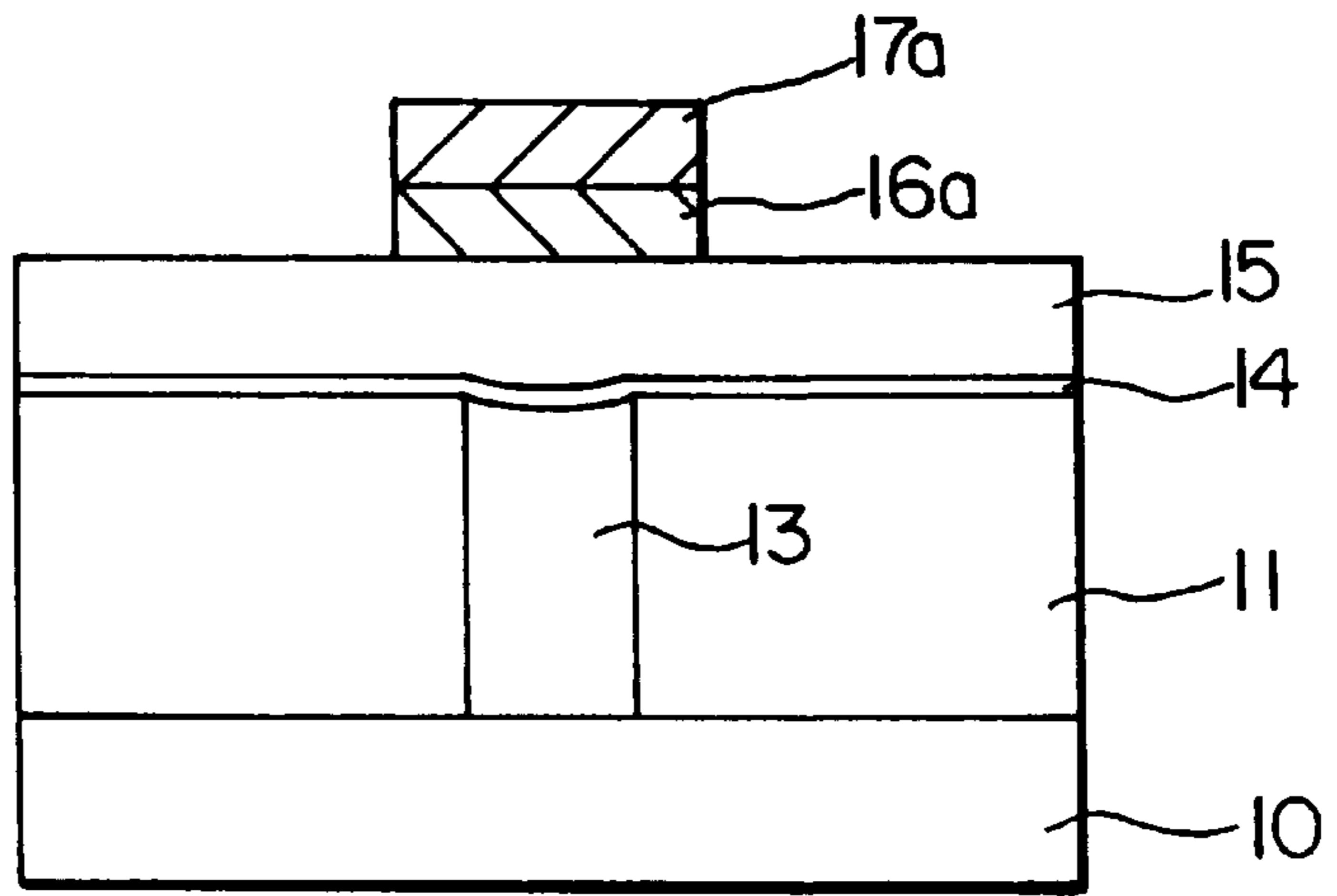


FIG. 2F

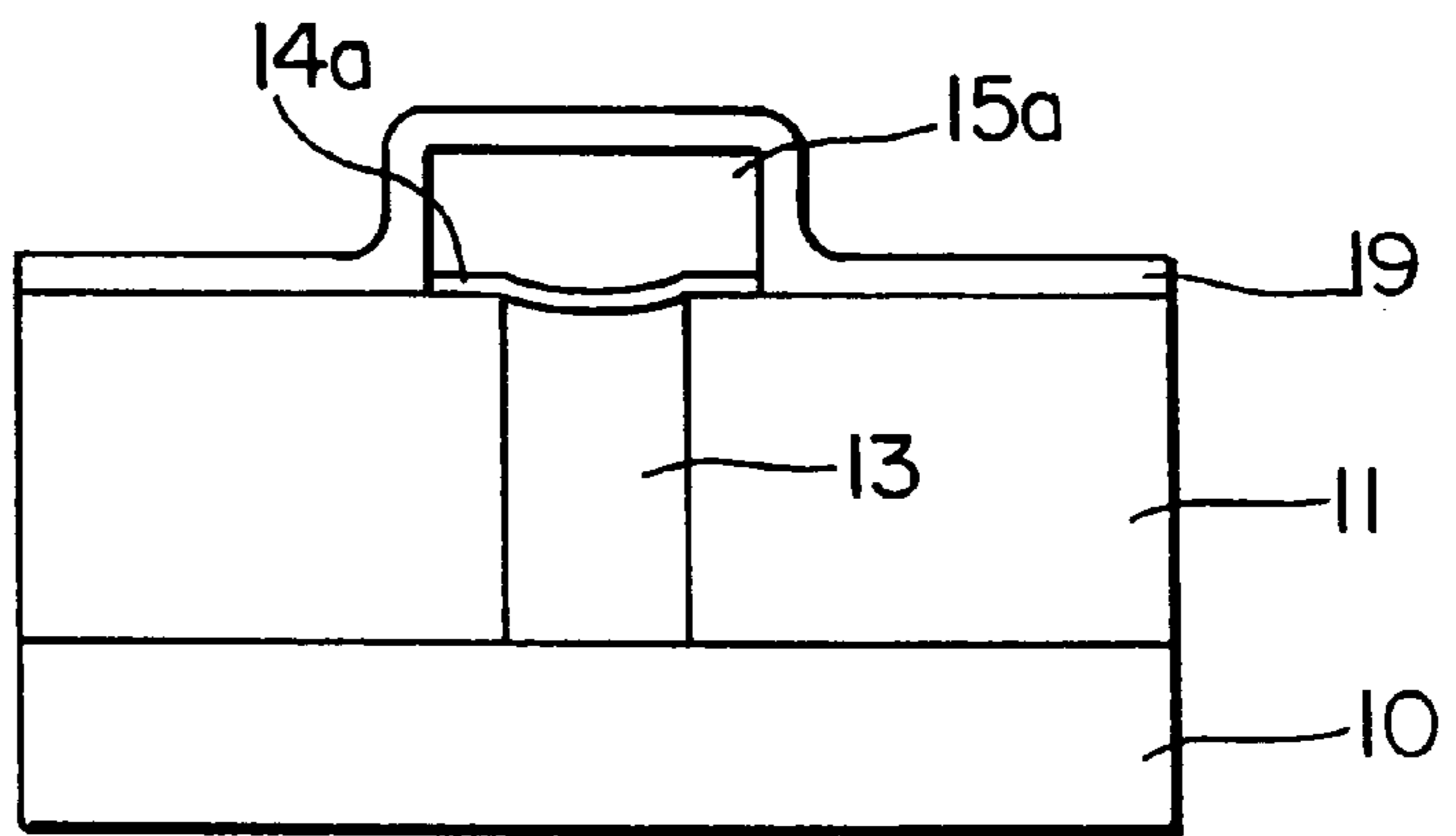


FIG. 2G

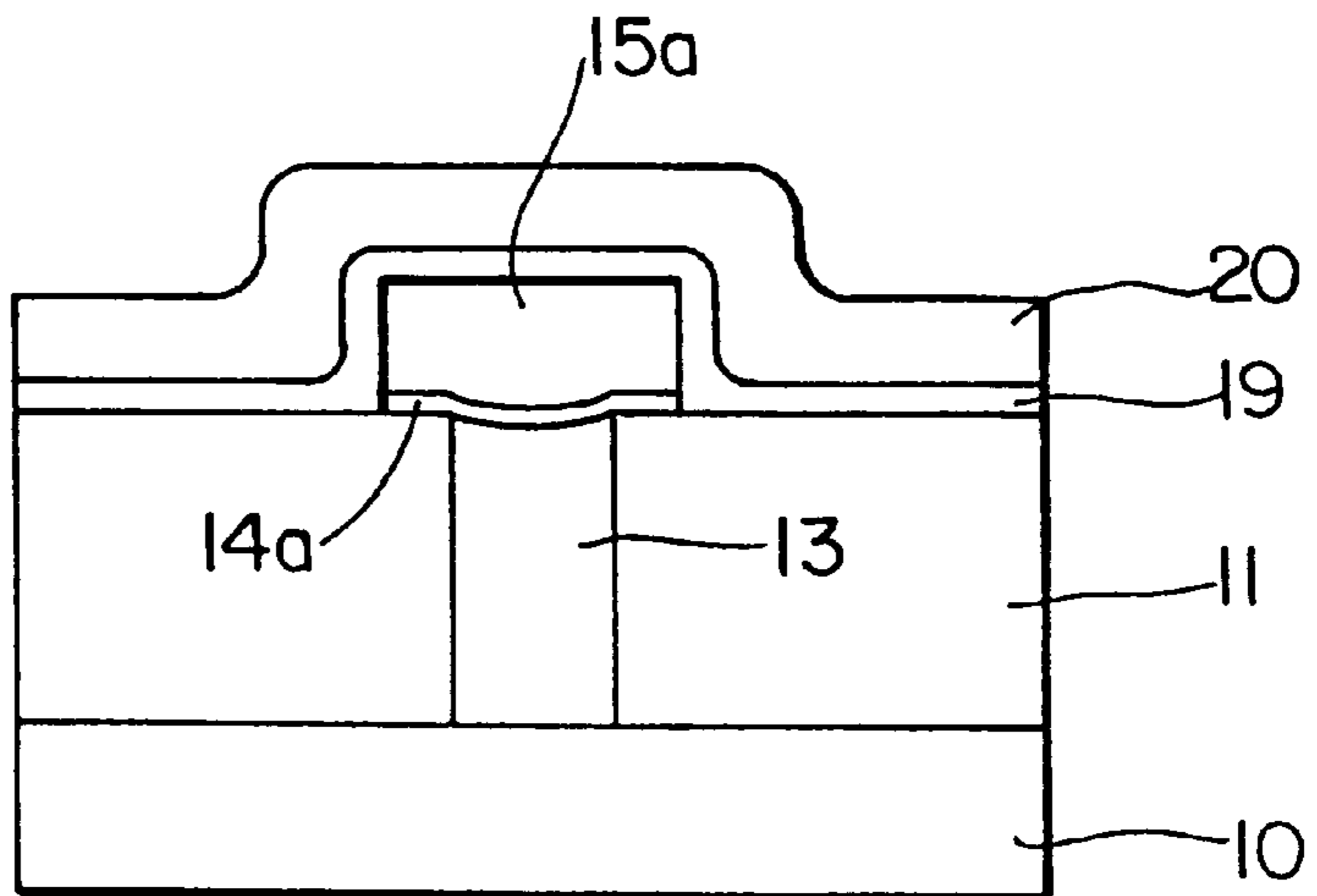


FIG. 3A

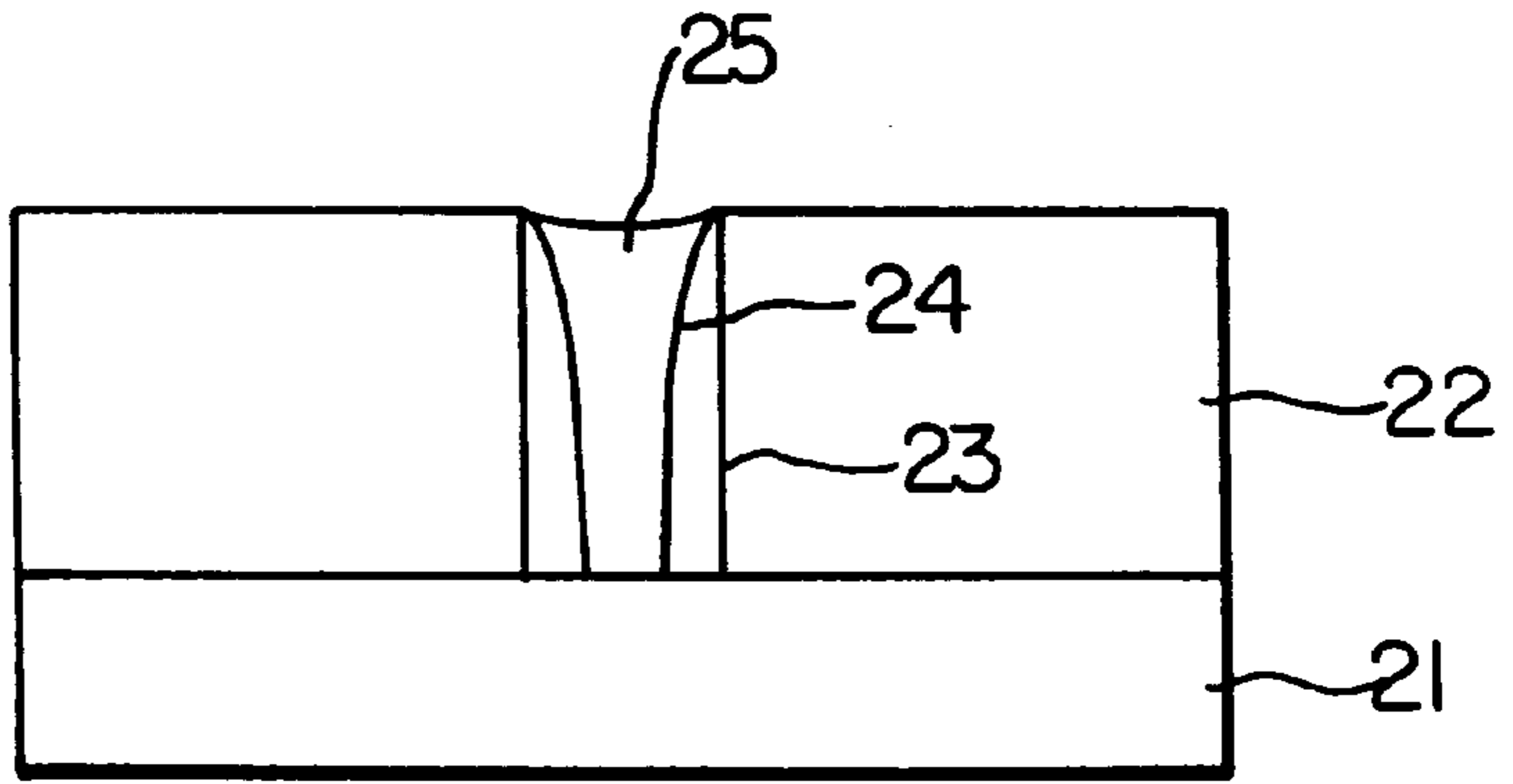


FIG. 3B

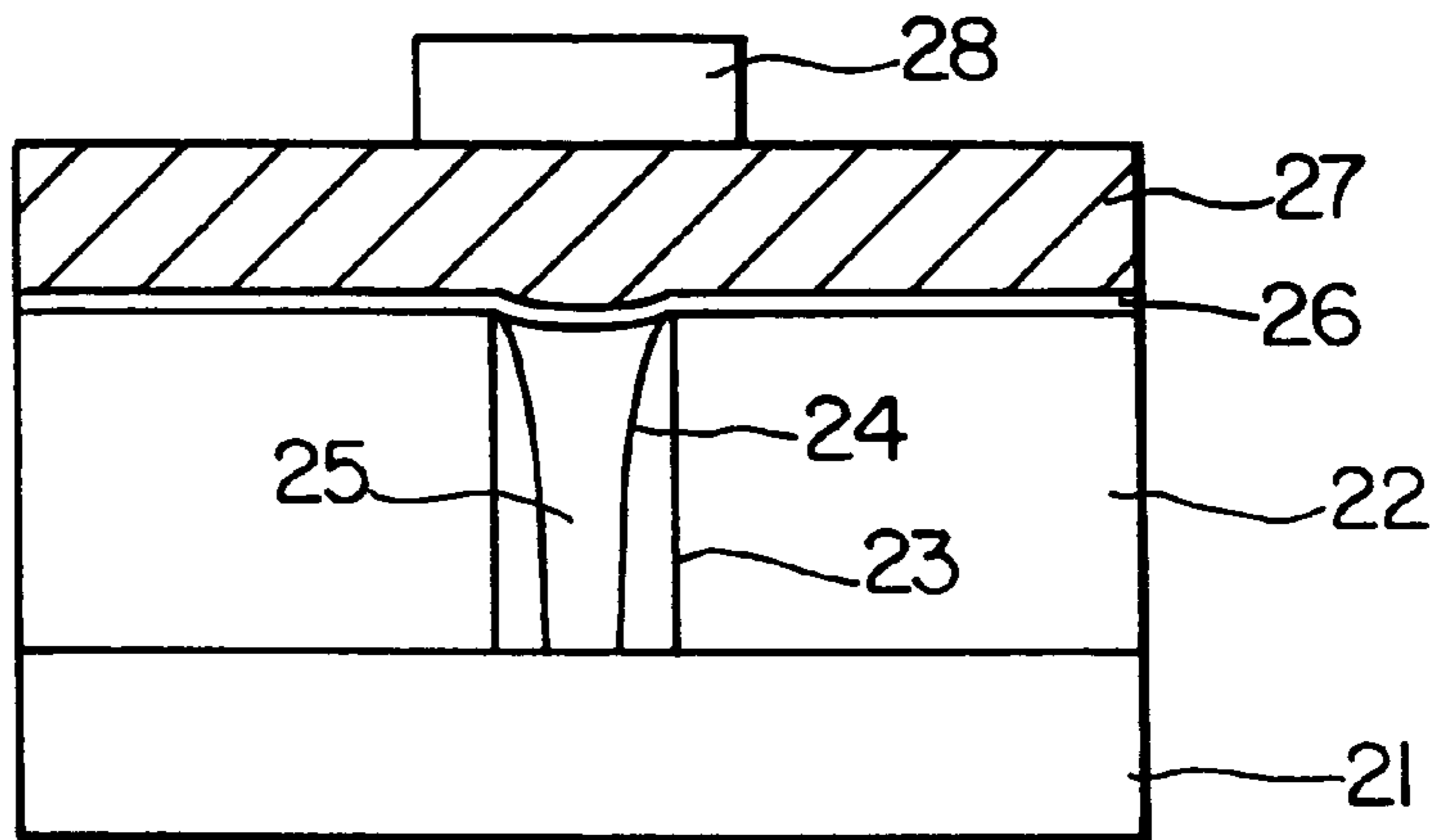
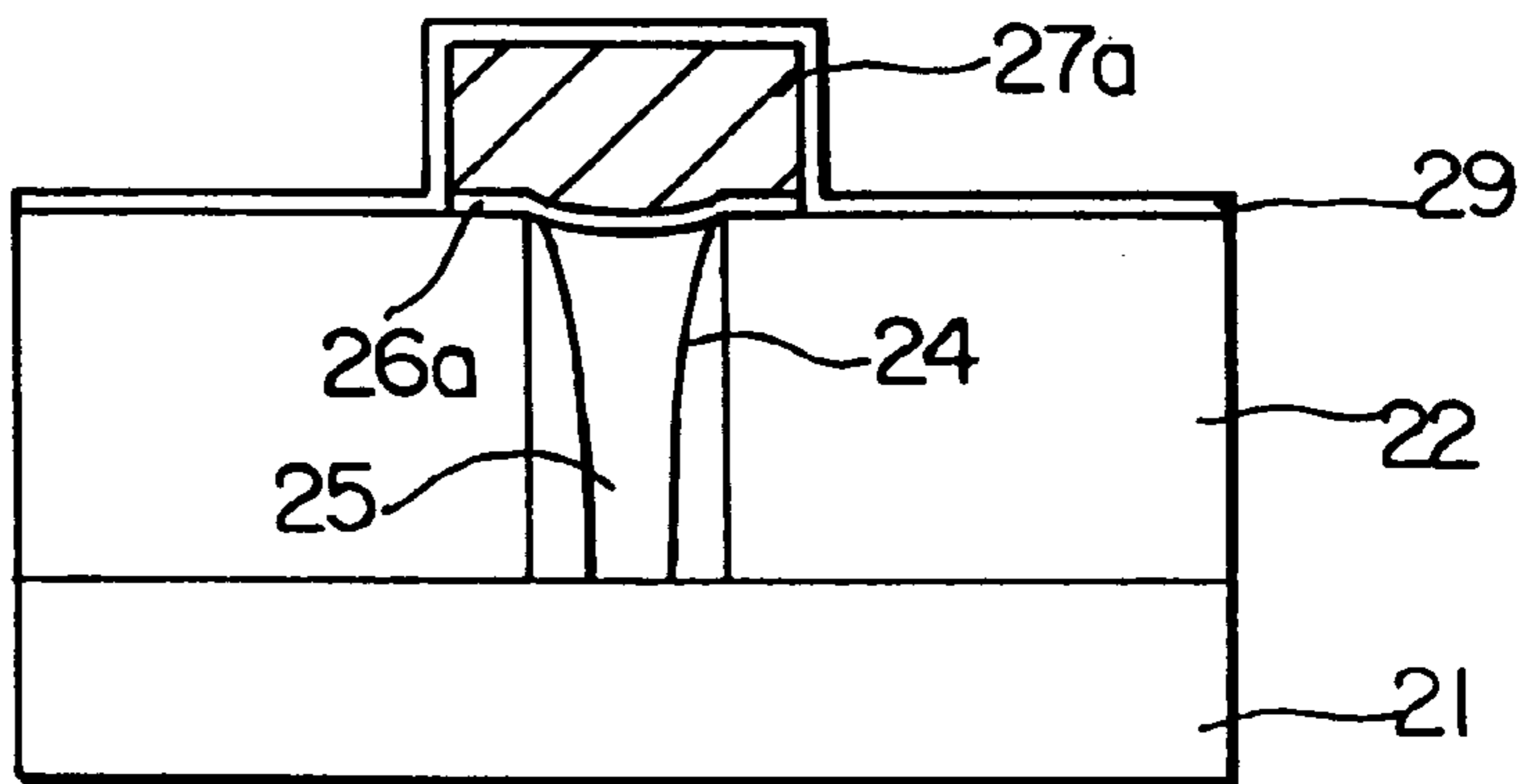
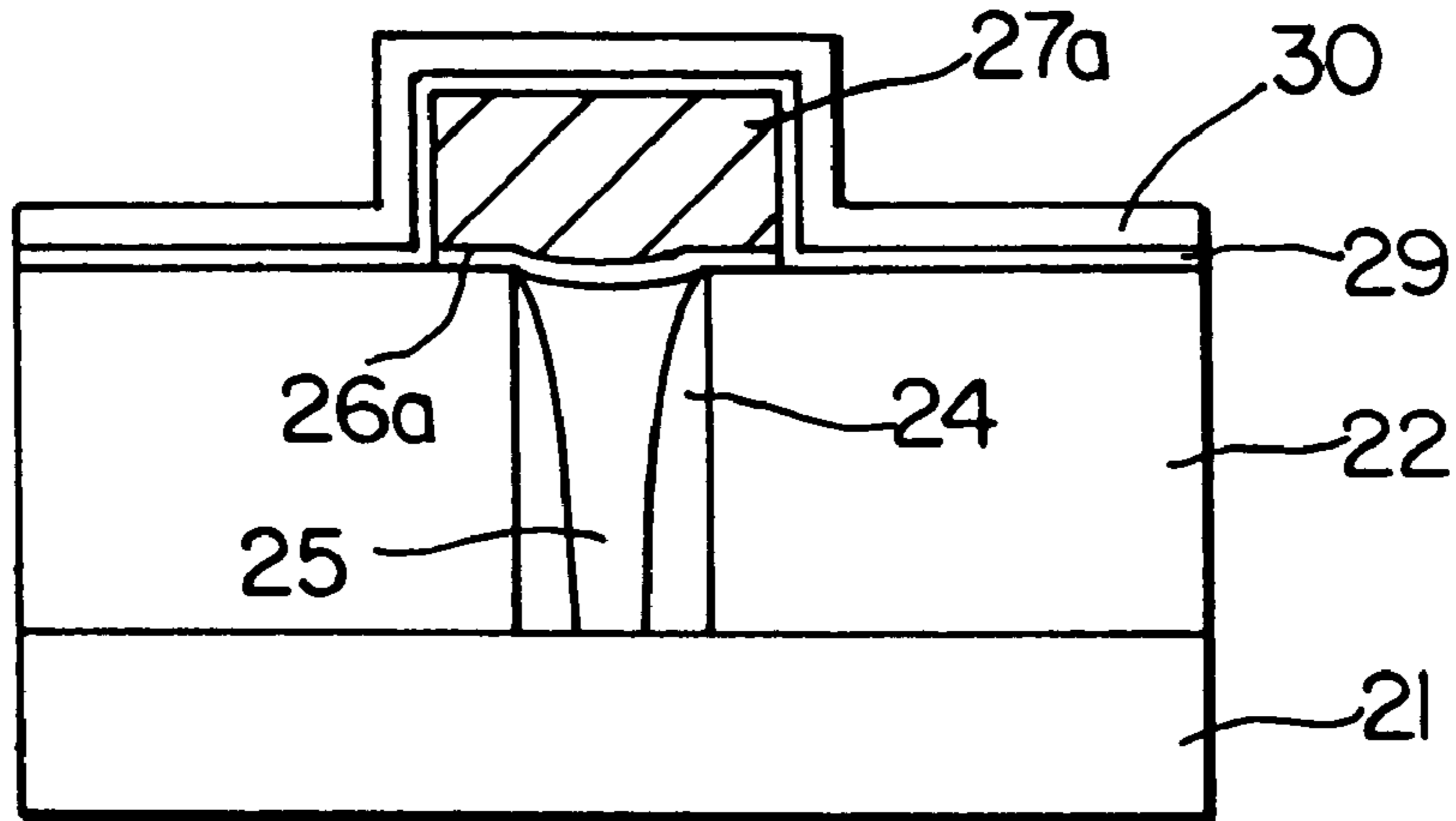
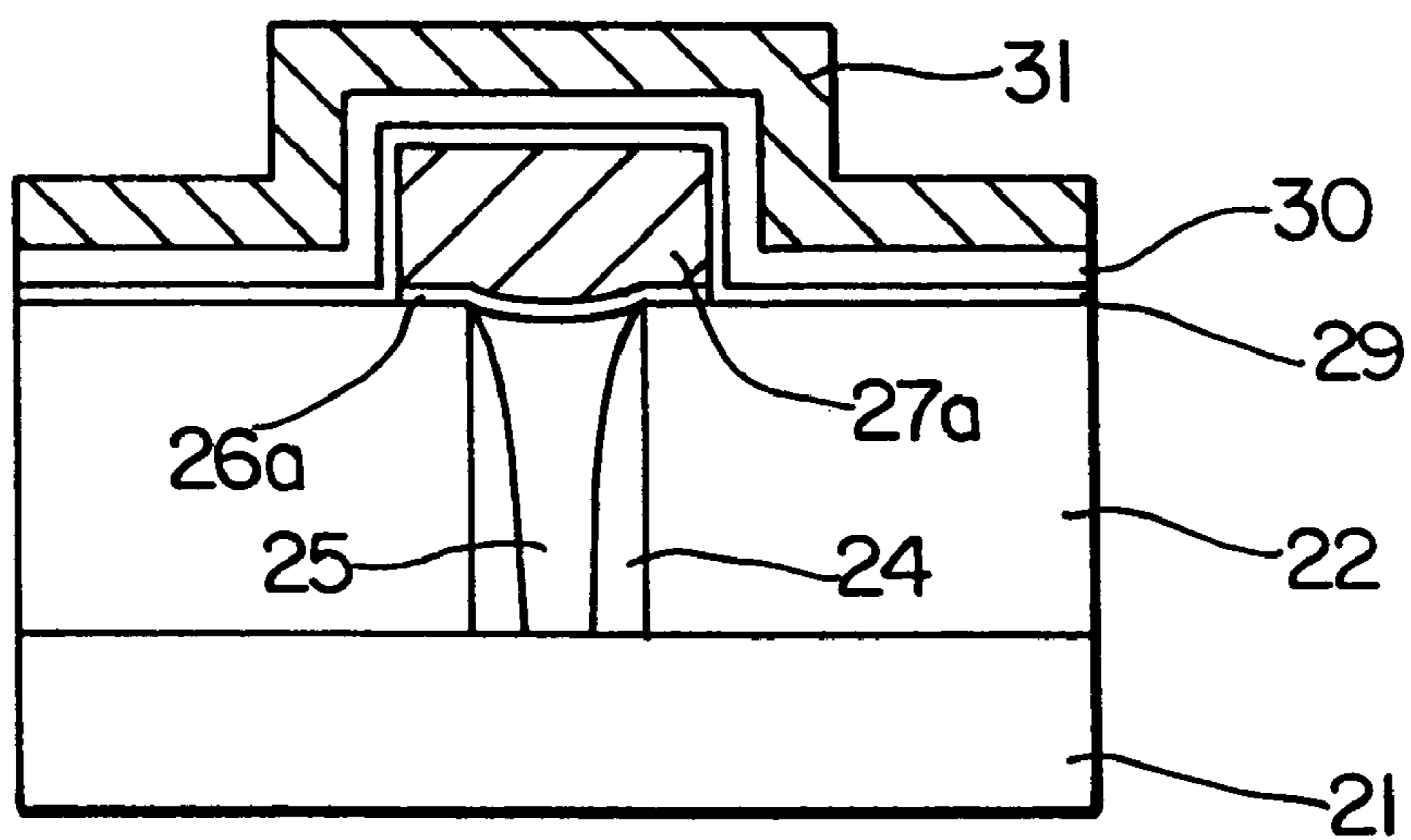


FIG. 3C





*FIG. 3D*



*FIG. 3E*

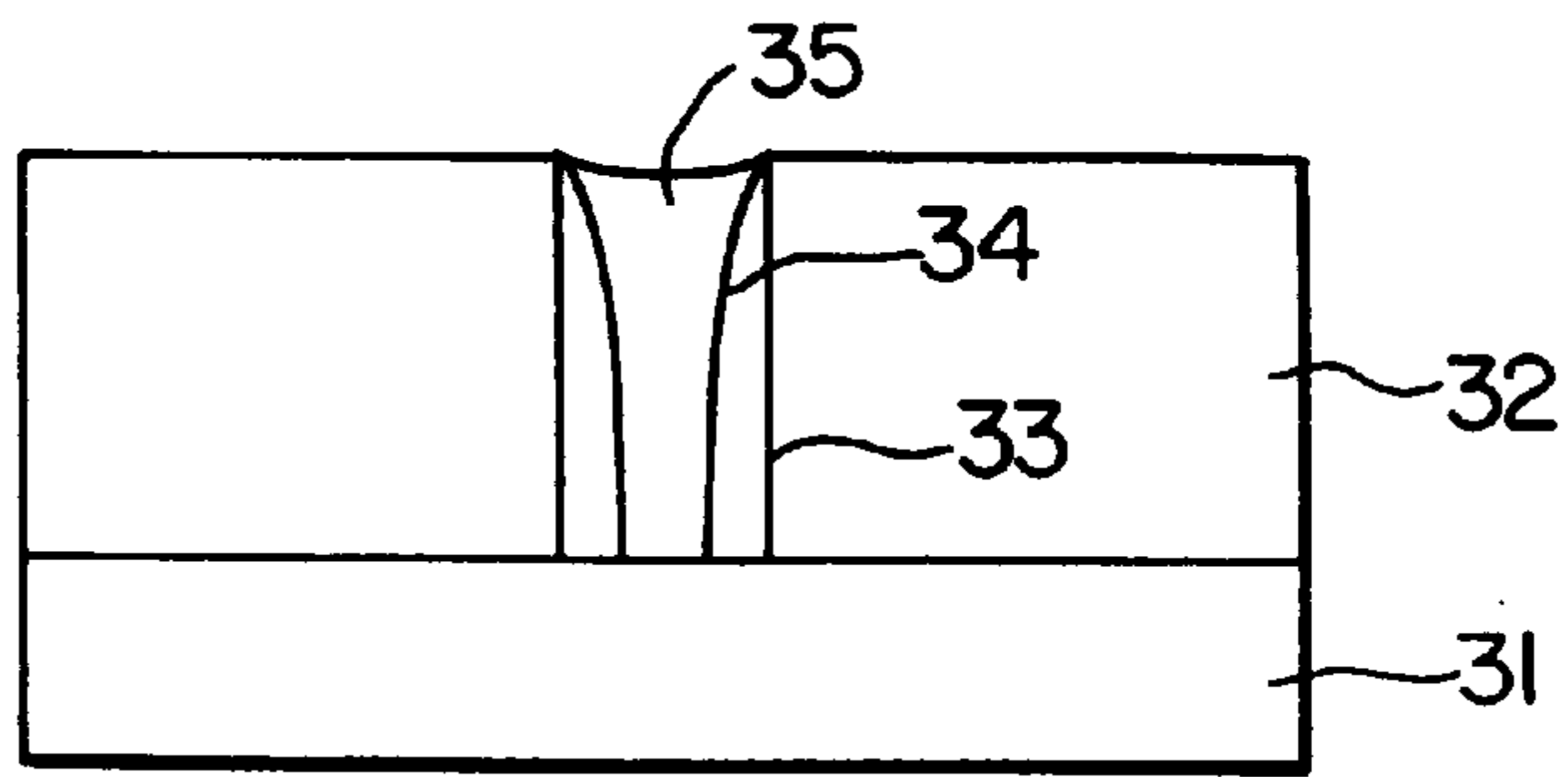


FIG. 4A

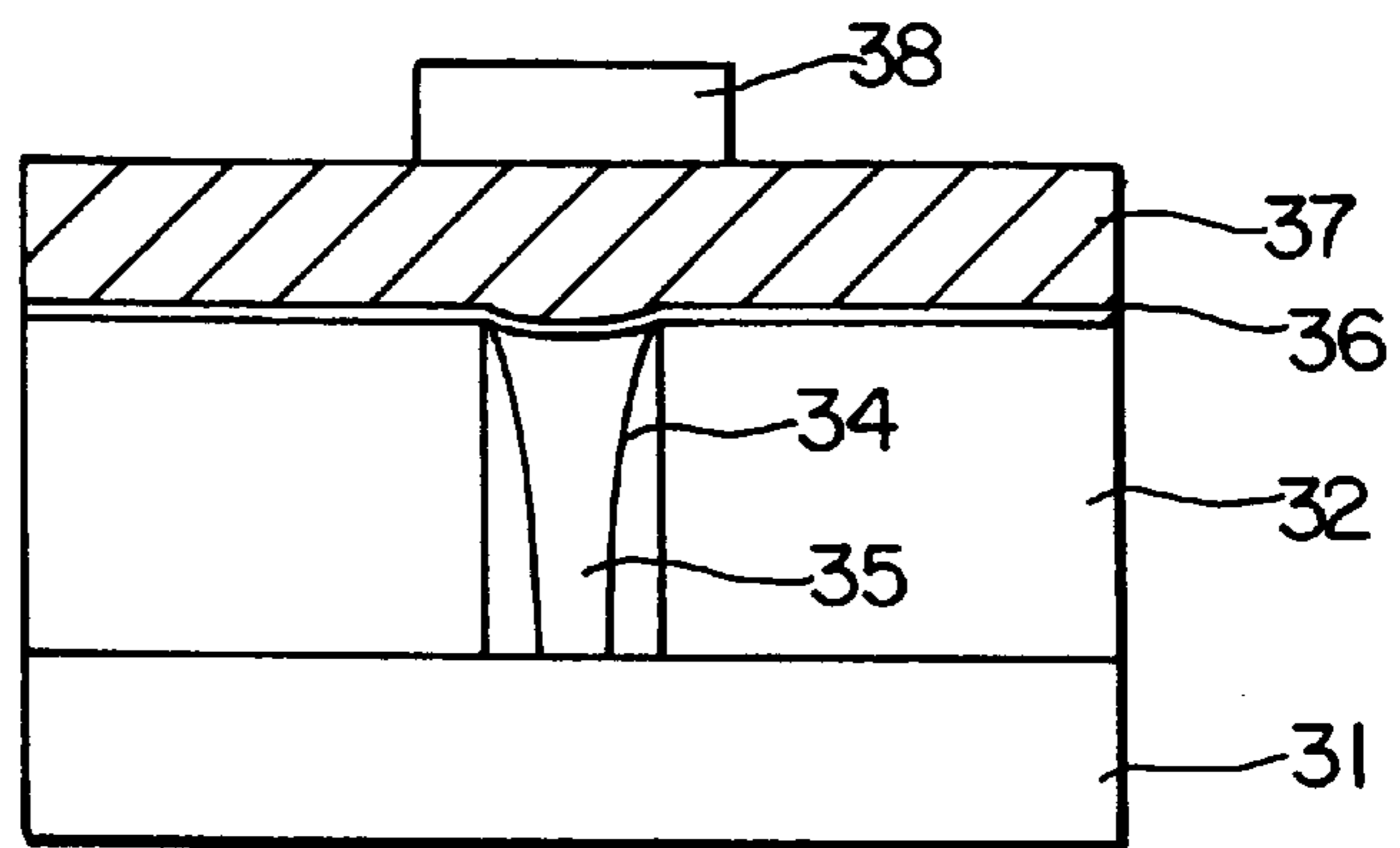


FIG. 4B

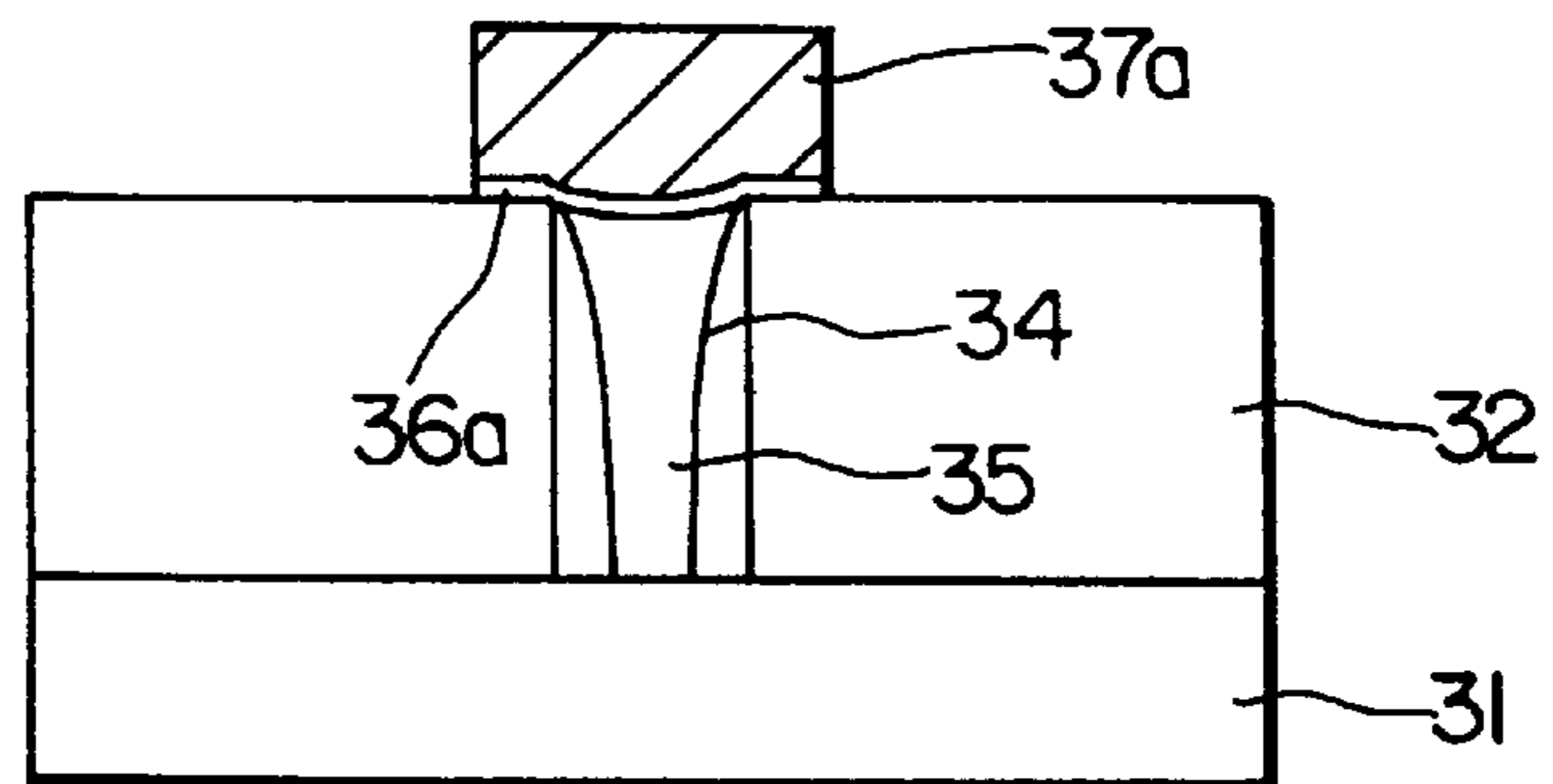


FIG. 4C

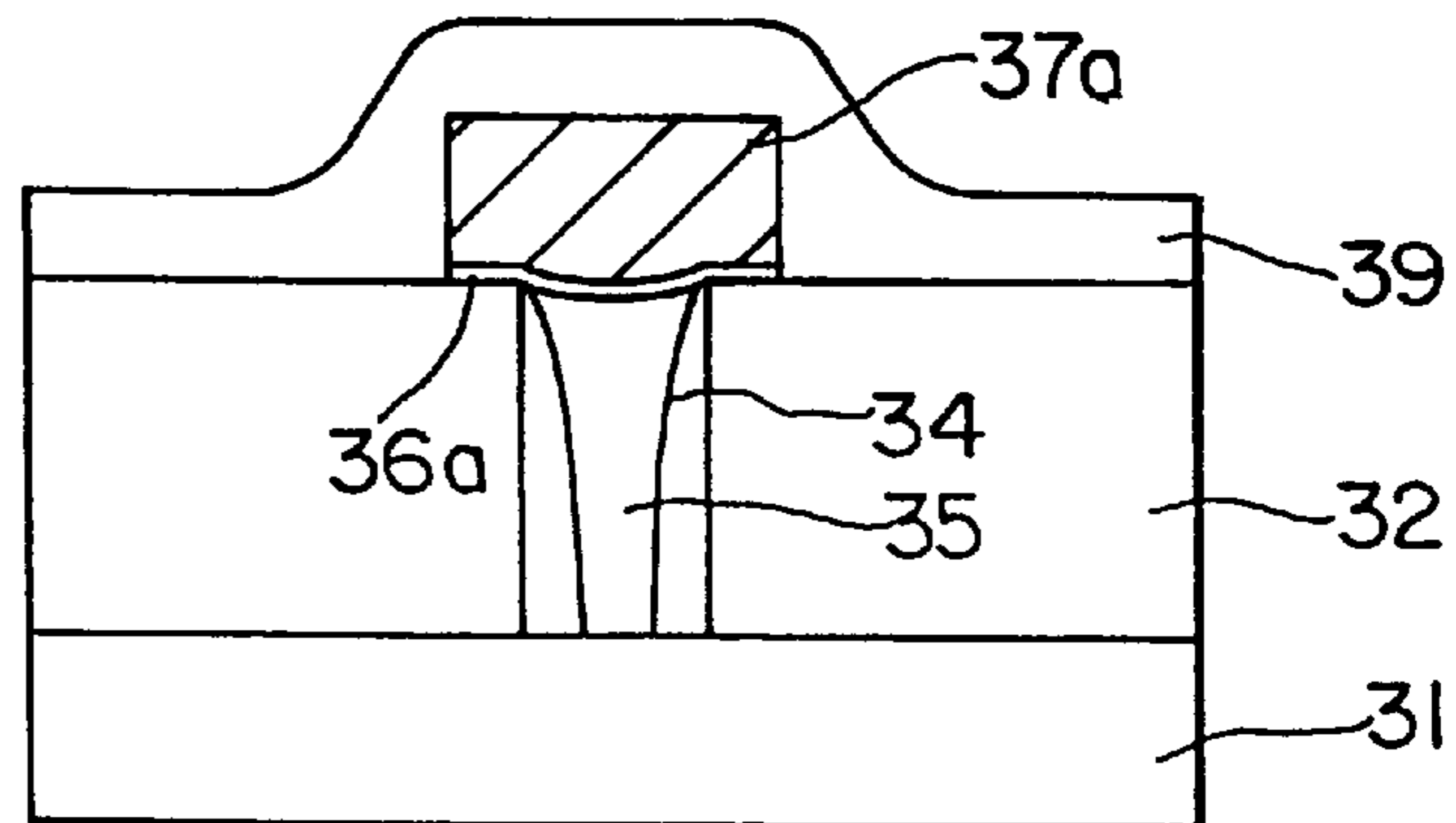


FIG. 4D

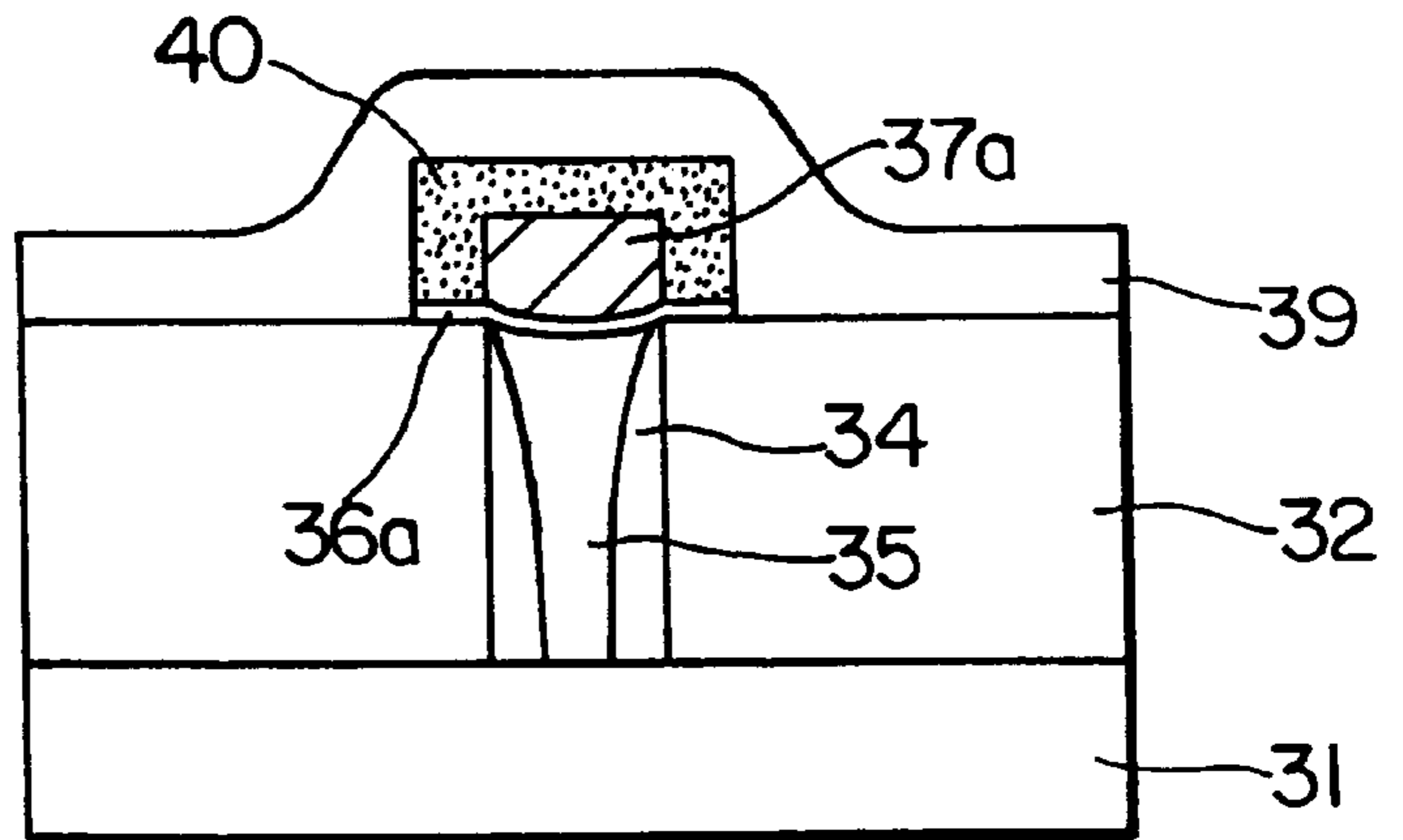


FIG. 4E

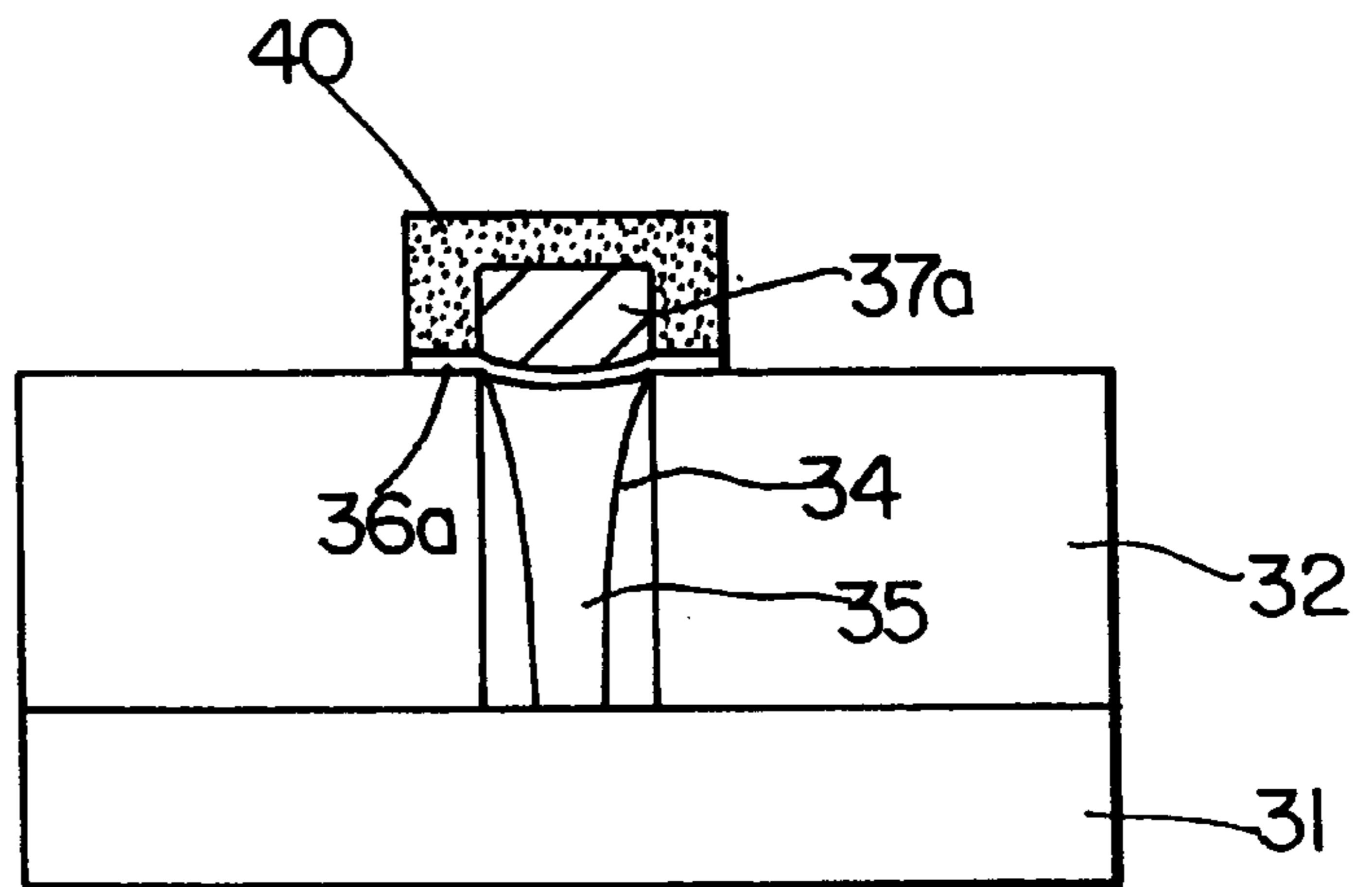


FIG. 4F

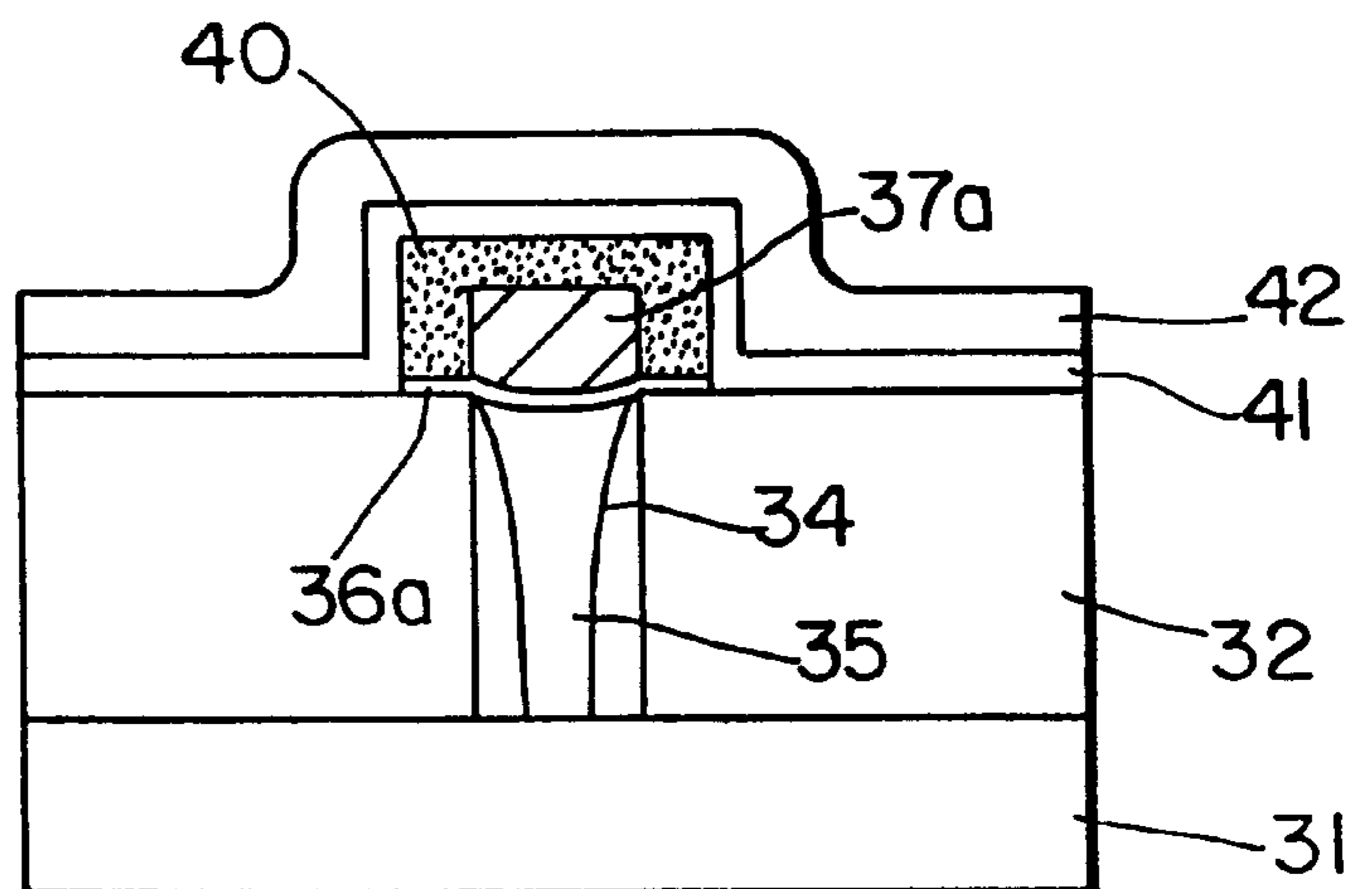


FIG. 4G



## METHOD FOR FABRICATING A CAPACITOR OF A SEMICONDUCTOR DEVICE

This is a divisional of U.S. application Ser. No. 08/670, 592, filed Jun. 26, 1996, U.S. Pat. No. 5,702,970.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to method for fabricating a semiconductor device and more particularly, with a method for fabricating a capacitor of a semiconductor device which is especially suitable for a highly-integrated semiconductor device.

#### 2. Description of the Prior Art

Generally, in fabricating a semiconductor device, the devices are implemented in higher integration and so the cells become smaller. Consequently securing sufficient capacitance in proportion to the surface area of the storage electrode has become a big smaller.

Particularly, in a DRAM in which a unit cell is comprised of a single MOS transistor and a capacitor, it is important for the high integration of the DRAM to reduce the area of the capacitor which takes a large part of the area in the chip at the same time with enlarging the capacitance of the capacitor.

In the meantime, the capacitance  $C$  is calculated by an equation,

$$C=(E0 \cdot Er \cdot A)/T,$$

in which  $E0$ ,  $Er$ ,  $A$ , and  $T$  mean respectively, a vacuum dielectric constant, a dielectric constant of a dielectric film, an area of the capacitor, and a thickness of the dielectric film, that is, the larger the specific dielectric constant  $Er$  of the dielectric film and the lesser the thickness  $T$  of the dielectric film, the larger the capacitance of  $C$ . Therefore, to achieve the high integration of the semiconductor device, it is preferred that the dielectric film is thin and made from a material having a high dielectric constant.

However, in the case in which the dielectric film is thin and made from a material having a high dielectric constant, the electric characteristic of the device becomes unstable and the reproduction characteristic thereof deteriorates due to the hillock and pin hole phenomena which occurs on a surface of the lower electrode to form a capacitor.

Therefore, a process has recently been proposed to absolve the above problem. In this process, an upper electrode and a lower electrode are formed by means of ruthenium oxide ( $RuO_2$ ), and then their operational characteristic is stabilized by heat treatment.

The conventional process will be described hereinafter with reference to FIGS. 1A to 1C which are schematic cross sectional views of a semiconductor device for showing the steps of the conventional process.

First, a lower insulating layer **2** is formed on a semiconductor substrate **1** as shown in FIG. 1A. Thereafter, the lower insulating layer **2** is selectively etched by means of a contact mask (not shown) for a capacitor so that a contact hole **3** for exposing that predetermined portions of the semiconductor substrate **1** is formed.

Thereafter, a polycrystalline silicon film (not shown) is formed on the entire exposed surface, and then the polycrystalline silicon film is etched so as to form a plug **4** in the contact hole **3**.

Then, as shown in FIG. 1B, a first ruthenium oxide ( $RuO_2$ ) film **5**, to be used as a lower electrode of the

capacitor, is formed on the entire plug **4** and a part of the lower insulating layer **2**, in the vicinity of the plug **4**. Thereafter, dielectric material is deposited on the first ruthenium oxide film **5** so as to form a dielectric film **6**.

Thereafter, as shown in FIG. 1C, a second ruthenium oxide ( $RuO_2$ ) film **7**, to be used as an upper electrode of the capacitor, is formed on the dielectric film **6** so that the manufacture of the capacitor is completed.

In this case, the first and the second ruthenium oxide films **5** and **7** are formed by means of ruthenium target and oxygen gas or according to a process in which ruthenium is deposited by the chemical vapor deposition (CVD) method and is then oxidized in a tube through annealing treatment.

The following is a discussion of the problems of the conventional method for fabricating a capacitor of a semiconductor device, as described above.

In the conventional method for fabricating a capacitor of a semiconductor device, in case where the ruthenium oxide films are formed by means of ruthenium target and oxygen gas, stable ruthenium oxide films are difficult to form due to the low oxidation speed of the ruthenium.

Furthermore, when partial pressure of the oxygen gas is high,  $RuO_3$  gas or  $RuO_4$  gas, which has a strong volatility, is generated, and thus, the thin film is volatilized.

Moreover, in a case where ruthenium is deposited by the CVD method and is then oxidized in a tube through the annealing treatment when the ruthenium oxide film ( $RuOx$ ) is formed in the conventional method for fabricating a capacitor of a semiconductor device,  $RuO_3$  gas or  $RuO_4$  gas, which has a higher volatility than that of the ruthenium oxide film, is generated when the ruthenium is oxidized in the tube, and thereby the tin film is volatilized.

Therefore, in the conventional method for fabricating a capacitor of a semiconductor device, due to the phenomenon that the thin film is volatilized, a desirable capacitor is not formed. Furthermore, the reliability and the operational characteristic of the semiconductor device deteriorates.

In other words, because the thin film is volatilized and degraded due to oxide generated during the formation of the pattern, the reliability and the operational characteristic of the semiconductor device deteriorates.

Therefore, the conventional method for fabricating a capacitor of a semiconductor device is not suitable for the high integration of the semiconductor device.

### SUMMARY OF THE INVENTION

The present invention has been made to overcome the above described problems of the prior arts, and accordingly, it is an objective of the present invention to provide a method for fabricating a capacitor of a semiconductor device which stabilizes the operational characteristic of the electrodes of the capacitor, thereby improving the operational characteristic and the reliability of the semiconductor device.

It is another objective of the present invention to provide a method for fabricating a capacitor of a semiconductor device which is suitable for the high integration of the semiconductor device.

To achieve the above objectives, the present invention provides a method for fabricating a capacitor of a semiconductor device, the method comprising the steps of: preparing a semiconductor substrate; forming an insulating layer on the semiconductor substrate; forming a contact hole which exposes the semiconductor substrate, by selectively eliminating the lower insulating layer; forming a plug in the contact hole; forming a titanium/titanium nitride film on the plug and the lower insulating layer; forming a first ruthenium

nium oxide film on the titanium/titanium nitride film; forming a first spin on glass film on the first ruthenium oxide film; implanting impurities into a surface of the first spin on glass film; forming a second spin on glass film on the first spin on glass film, and then selectively eliminating the first and the second spin on glass films; etching the first ruthenium oxide film and the titanium/titanium nitride film by utilizing the second and the first spin on glass films as a mask; eliminating the second and the first spin on glass films, and then forming a dielectric film on an exposed surface of the first ruthenium oxide film, the titanium/titanium nitride film, and the lower insulating layer, with the dielectric film having a specific dielectric constant; and forming a second ruthenium oxide film on the dielectric film.

Another aspect of the present invention provides a method for fabricating a capacitor of a semiconductor device, the method comprising the steps of: preparing a semiconductor substrate; forming an insulating layer on the semiconductor substrate; forming a contact hole which exposes the semiconductor substrate, by selectively eliminating the lower insulating layer; forming a plug in the contact hole; forming a first titanium nitride film on the plug and the lower insulating layer; forming a ruthenium oxide film on the first titanium nitride film; etching selectively the ruthenium oxide film and the first titanium nitride film; forming a dielectric film having a high specific dielectric constant, on an exposed surface of the ruthenium oxide film, the first titanium nitride film, and the lower insulating layer; forming a tungsten silicide film, a second titanium nitride film, and a polycrystalline silicon film on the dielectric film in serial order.

Another aspect of the present invention provides a method for fabricating a capacitor of a semiconductor device, the method comprising the steps of: preparing a semiconductor substrate; forming an insulating layer on the semiconductor substrate; forming a contact hole which exposes the semiconductor substrate, by selectively eliminating the lower insulating layer; forming a plug in the contact hole; forming a titanium/titanium nitride film and a first ruthenium oxide film on the plug and the lower insulating layer; eliminating selectively the first ruthenium oxide film and the titanium/titanium nitride film; forming a second ruthenium oxide film on the first ruthenium oxide film selectively eliminated; and forming a dielectric film having a high specific dielectric constant, on an exposed surface of the second ruthenium oxide film, the titanium/titanium nitride film, and the lower insulating layer, and then forming an upper electrode on the dielectric film.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood and its various objects and advantages will be more fully appreciated from the following description taken in conjunction with the accompanying drawings in which:

FIGS. 1A to 1C are schematic cross sectional views of a semiconductor device which show the steps of a conventional method for fabricating a capacitor of a semiconductor device;

FIGS. 2A to 2G are schematic cross sectional views of a semiconductor device which show the steps of a method for fabricating a capacitor of a semiconductor device according to the first embodiment of the present invention;

FIGS. 3A to 3E are schematic cross sectional views of a semiconductor device which show the steps of a method for fabricating a capacitor of a semiconductor device according to the second embodiment of the present invention; and

FIGS. 4A to 4G are schematic cross sectional views of a capacitor semiconductor which show the steps of a method

for fabricating a capacitor of a semiconductor device according to the third embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, several embodiments of the present invention will be described in detail with reference to the drawings.

FIGS. 2A to 2G are schematic cross sectional views of a semiconductor device which show the steps of a method for fabricating a capacitor of a semiconductor device according to the first embodiment of the present invention.

First, a semiconductor substrate **10** is prepared and a lower insulating layer **11** is formed on the semiconductor substrate **10** as shown in FIG. 2A. In this case, the lower insulating layer **11** is formed by depositing insulating material so as to make the surface of the layer even, after forming an element which isolates insulation film, a gate electrode, and bit line (all not shown).

Thereafter, the lower insulating layer **11** is selectively etched by means of a capacitor contact mask (not shown), so that a contact hole **12** for exposing that a predetermined portion of the semiconductor substrate **10** is formed.

Thereafter, a polycrystalline silicon film (not shown) is formed on the entire upper surface of the construction, and then the polycrystalline silicon film is etched so as to form a plug **13** of the polycrystalline silicon film in the contact hole **12**.

Then, as shown in FIG. 2B, a titanium/titanium nitride film (TiN) **14** and a first ruthenium oxide (RuO<sub>2</sub>) film **15** are formed in serial order on the entire surface of the resultant construction.

In this case, the titanium/titanium nitride film **14** is deposited with a thickness between about 100 Å and about 1000 Å by utilizing chemical vapor deposition (CVD) or physical vapor deposition (PVD) in a selective manner.

Especially when the CVD method is used, the titanium/titanium nitride film **14** is formed by depositing TiCl<sub>4</sub>/NH<sub>3</sub> gas under a temperature between about 500° C. and about 700° C., or is formed in a CVD reactor under a temperature between about 300° C. and about 500° C. by means of the thermal decomposing reaction of tetra-di-ethyl-amido-titanium (TDEAT) or tetra-di-methyl-amido-titanium (TDMAT) which is a metal organic compound.

Furthermore, the first RuO<sub>2</sub> film **15** is formed with a thickness between about 2000 Å and 5000 Å by means of ruthenium target and oxygen/argon gas in a sputtering reactor under a temperature between about 25° C. and 500° C. by direct current (DC) or radio frequency (RF) current.

Thereafter, a first spin on glass (SOG) film **16** is formed with a predetermined thickness on the first RuO<sub>2</sub> film **15**, as shown in FIG. 2C. Preferably, the thickness of the first SOG film **16** may be between about 500 Å and 1500 Å.

Then, the impurity ions are implanted into the first SOG film **16**. It is preferred that platinum is used for the impurity ions.

Meanwhile, in implanting the impurity ions in the first SOG film **16**, a gas of Pt(CO)<sub>2</sub>Cl<sub>2</sub> is utilized with a concentration of 10<sup>19</sup> ions/cm<sup>2</sup> and energy of more than 1 KeV, so that the impurity ions can be implanted through the first SOG film **16** into the surface area of the first RuO<sub>2</sub> film **15**. The first SOG film **16** prevents the first RuO<sub>2</sub> film **15** from being damaged due to the above ion implanting process.

Thereafter, a second SOG film **17** is formed with a predetermined thickness on the first SOG film **16**. It is preferred that the thickness of the second SOG film **17** may be between about 1000 Å and about 3500 Å.

Thereafter, as shown in FIG. 2D, a photoresist film pattern **18** is formed on the second SOG film **17** through an etching process by means of a storage electrode mask (not shown).

Thereafter, the second SOG film **17** and the first SOG film **16** are etched in serial order, as shown in FIG. 2E, by utilizing the photoresist film pattern **18** as a mask, and then the photoresist film pattern **18** is eliminated. In this case, the above etching is carried out by means of  $\text{CHF}_3/\text{CF}_4$  solution in a reactive ion etching (RIE) reactor.

Then, the first  $\text{RuO}_2$  film **15** and the titanium/titanium nitride film **14** are etched in serial order by utilizing the second and the first SOG film **17a** and **16a**, as a mask, which remains thereon after the etching, as shown in FIG. 2F. In this case, this etching is carried out by means of  $\text{Cl}_2/\text{O}_2$ , Ar gas in an RIE reactor.

Thereafter, a dielectric film **19** is formed on the entire upper exposed surface. In this case, the dielectric film **19** is formed with a thickness between about 300 Å and 700 Å by means of  $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{TiO}_3$  (BST) target under a temperature between about 25° C. and 700° C. by an electric power between about 50 W and 300 W. In addition, the dielectric film **19** is formed by using PVD or CVD method in a selective manner.

Particularly when the CVD method is used, the dielectric film **19** is deposited by using  $\text{Ti}(\text{T}-\text{OC}_3\text{H}_7)_4$ ,  $\text{Sr}(\text{DPM})_2$ , and  $\text{Ba}(\text{DPM})_2$  as raw gases. Also, the dielectric film **19** may be formed by utilizing lead zirconate titanate (PZT) as raw material.

After the formation of the dielectric film **19**, a second  $\text{RuO}_2$  film **20** which is to serve as a plate electrode is formed on the dielectric film **19** as shown in FIG. 2G. In this case, the second  $\text{RuO}_2$  film **20** is formed with a thickness between about 1000 Å and 3000 Å. Further, the formation of the second  $\text{RuO}_2$  film **20** is carried out under a temperature between about 300° C. and 600° C. by means of  $\text{Ru}(\text{DPM})_3$  and  $\text{O}_2$  gas or  $\text{Ru}(\text{DPM})_3$  and  $\text{O}_3$  gas in a low pressure chemical vapor deposition (LPCVD) reactor.

A method for fabricating a capacitor of a semiconductor device according to the second embodiment of the present invention will be described in detail hereunder with reference to the drawings.

FIGS. 3A to 3E are schematic cross sectional views of a semiconductor device for showing the steps of the method for fabricating a capacitor of a semiconductor device according to the second embodiment of the present invention.

At first, a lower insulating layer **22** is formed on a semiconductor substrate **21** as shown in FIG. 3A. In this case, the lower insulating layer **22** is formed by depositing insulating material after forming an element isolating insulation film, a gate electrode, and bit line (all now shown).

Thereafter, the lower insulating layer **22** is selectively etched by means of a capacitor contact mask (not shown), so that a contact hole **23**, which exposes a predetermined portion of the semiconductor substrate **21**, is formed.

After the contact hole **23** is arranged, an oxide film spacer **24** is formed on the inner side wall of the contact hole **23**.

Thereafter, a polycrystalline silicon film (not shown) is formed with a certain thickness throughout the entire upper surface of the construction, and then the polycrystalline silicon film is etched so as to form a plug **25** of the polycrystalline silicon film in the contact hole **23**.

Then, as shown in FIG. 3B, a first titanium nitride film **26** and an  $\text{RuO}_2$  film **27** are formed in serial order throughout the entire surface of the resultant construction.

In this case, the first titanium nitride film **26** is deposited with a thickness between about 100 Å and about 500 Å by

utilizing chemical vapor deposition (CVD) or physical vapor deposition (PVD) in a selective manner.

Particularly when the CVD method is used, the titanium/titanium nitride film **14** is formed by depositing  $\text{TiCl}_4/\text{NH}_3$  gas under a temperature between about 500° C. and 700° C., or is formed in a CVD reactor under a temperature between about 300° C. and 500° C. by means of the thermal decomposing reaction of tetra-di-ethyl-amido-titanium (TDEAT) or tetra-di-methyl-amido-titanium (TDMAT) which is a metal organic compound.

Furthermore, the  $\text{RuO}_2$  film **27** is formed with a thickness between about 2000 Å and 5000 Å by means of ruthenium target and oxygen/argon gas under a temperature between about 25° C. and 500° C. by direct current (DC) or radio frequency (RF) current.

Thereafter, a photoresist film pattern **28** is formed on the ruthenium oxide film **27** through an etching process by means of a storage electrode mask (not shown).

Thereafter, as shown in FIG. 3C, the  $\text{RuO}_2$  film **27** and the first titanium nitride film **26** are etched in serial order by utilizing the photoresist film pattern **28** as a mask, and then the photoresist film pattern **28** is eliminated. In this case, the above etching of the  $\text{RuO}_2$  film **27** and the first titanium nitride film **26** is carried out by means of  $\text{Cl}_2/\text{O}_2$  gas in RIE reactor.

Thereafter, a dielectric film **29**, a BST film, is formed on the  $\text{RuO}_2$  film **27a** and the first titanium nitride film **26a** remaining after the etching of the films **27** and **26** by depositing BST material with a predetermined thickness thereon. In this case, the BST film **29** is formed with a thickness between about 300 Å and 700 Å by means of  $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{TiO}_3$  (BST) target under a temperature between about 25° C. and about 700° C. with electric power between about 50 W and 300 W. In addition, the dielectric film **29** is formed by depositing dielectric material according to a CVD method.

In this case, the dielectric film **29** is deposited by using  $\text{Ti}(\text{T}-\text{OC}_3\text{H}_7)_4$ ,  $\text{Sr}(\text{DPM})_2$ , and  $\text{Ba}(\text{DPM})_2$  as the dielectric material. Also, the dielectric film **29** may be formed by means of PZT.

Thereafter, a tungsten silicide film **30** is formed with a predetermined thickness on the BST film **29**. Preferably, the thickness may be between about 50 Å and 900 Å. Furthermore, the formation of the tungsten silicide film **30** is carried out under a temperature between about 300° C. and 700° C. by means of  $\text{WF}_6$  and  $\text{SiH}_2\text{Cl}_2$  gas or  $\text{WF}_6$  and  $\text{SiH}_4$  gas in an LPCVD reactor.

In this case, the tungsten silicide film **30** prevents the BST film **29** from being contaminated by silicide and at the same time, reduces the stress in the BST film **29** and the upper electrode due to the succeeding high-temperature process.

Thereafter, as shown in FIG. 3E, a second titanium nitride film and a polycrystalline silicon film are deposited in serial order on the tungsten silicide film **30** so as to form a second titanium nitride/polycrystalline silicon multi-film **31** thereon.

In this case, the second titanium nitride film is deposited by means of the thermal decomposing reaction of TDEAT, TDMAT, or  $\text{TiCl}_4/\text{NH}_3$  under a temperature between about 200° C. and about 700° C. in a CVD reactor.

Moreover, the second titanium nitride film prevents diffusion of impurities between the upper electrode and the dielectric film, thereby maintaining the film characteristic of each film.

In addition, the polycrystalline silicon film is deposited with a thickness between about 1000 Å and 5000 Å by

utilizing  $\text{SiH}_4$  and  $\text{SiH}_2\text{Cl}_2$  as reacting gas under a temperature between about  $450^\circ\text{C}$ . and  $700^\circ\text{C}$ . in an LPCVD reactor.

In this case, the laminated construction of the tungsten silicide film **30** and second titanium nitride/polycrystalline silicon multi-film **31** serves as the upper electrode of the capacitor.

Another method for fabricating a capacitor of a semiconductor device according to the third embodiment of the present invention will be described in detail hereunder with reference to the drawings.

FIGS. **4A** to **4G** are schematic cross sectional views of a semiconductor device which show the steps of the method for fabricating a capacitor of a semiconductor device according to the third embodiment of the present invention.

At first, a lower insulating layer **32** is formed on a semiconductor substrate **31**, as shown in FIG. **4A**. In this case, the lower insulating layer **32** is formed by depositing insulating material after forming an element which isolates an insulation film, a gate electrode, and a bit line (all now shown).

Thereafter, the lower insulating layer **32** is selectively etched by means of a capacitor contact mask (not shown), so that a contact hole **33**, which exposes a predetermined portion of the semiconductor substrate **31**, is formed.

After the contact hole **33** is arranged, an oxide film spacer **34** is formed on the inner side wall of the contact hole **33**.

Thereafter, a polycrystalline silicon film (not shown) is formed with a certain thickness throughout the entire upper surface of the construction, and then the polycrystalline silicon film is etched so as to form a plug **35** of the polycrystalline silicon film in the contact hole **33**.

Then, as shown in FIG. **4B**, a first titanium/titanium nitride film **36** and a first  $\text{RuO}_2$  film **37** are formed in serial order throughout the entire surface of the resultant construction now.

In this case, the titanium film of the titanium/titanium nitride film **36** has a thickness between about  $100\text{ \AA}$  and  $300\text{ \AA}$ , and the titanium nitride film thereof has a thickness between about  $200\text{ \AA}$  and  $500\text{ \AA}$ .

Further, the first ruthenium oxide film **37** is formed with a thickness between about  $3000\text{ \AA}$  and  $5000\text{ \AA}$ . The first ruthenium oxide film **37** is deposited through sputtering, by means of ruthenium target, or by depositing  $\text{Ru}(\text{C}_3\text{H}_5)_2$ ,  $\text{Ru}(\text{NO})(\text{NO}_3)_3$ ,  $\text{RuO}_4$ ,  $\text{RuF}_5$ ,  $\text{H}_3\text{Ru}(\text{SO}_3)_2\text{OH}$ , and the like, under a temperature between about  $200^\circ\text{C}$ . and  $500^\circ\text{C}$ . through a CVD method.

Thereafter, a photoresist film pattern **38** is formed on the first ruthenium oxide film **37** through an etching process by means of a storage electrode mask (not shown).

Thereafter, as shown in FIG. **4C**, the first  $\text{RuO}_2$  film **37** and the titanium/titanium nitride film **36** are etched in serial order by utilizing the photoresist film pattern **38** as a mask, and then the photoresist film pattern **38** is eliminated. In this case, the above etching of the first  $\text{RuO}_2$  film **37** and the titanium/titanium nitride film **36** is carried out by utilizing the lower insulating layer **32** as an etching barrier.

Thereafter, as shown in FIG. **4D**, an SOG oxide film **39** is formed on the first  $\text{RuO}_2$  film **37a**, and the titanium/titanium nitride film **36a** remains after the etching of the films **37** and **36**. In this case, it is preferred that the SOG film **39** is formed with a thickness between about  $1000\text{ \AA}$  and  $5000\text{ \AA}$ .

Thereafter, as shown in FIG. **4E**, a second ruthenium oxide film **40** is formed by subjecting the entire construction

to annealing treatment for about 30 minutes to 120 minutes in a tube (not shown) at a temperature between  $400^\circ\text{C}$ . and  $800^\circ\text{C}$ .

In this case, the second ruthenium oxide film **40** is formed with a thickness between about  $300\text{ \AA}$  and  $500\text{ \AA}$  on the first ruthenium oxide film **37** because of the oxidation process in which oxygen in the SOG oxide film **39** is diffused into the first ruthenium oxide film **37**.

In the meantime, when the thickness of the second ruthenium oxide film **40** formed through the process shown by FIGS. **4D** and **4E**, is not sufficient, the SOG oxide film **39** may be formed to have a thickness of not more than  $500\text{ \AA}$ , and then may be subjected to an annealing treatment after implanting, thereunto, oxygen which serves as impurities, so that a proper and sufficient ruthenium oxide film may be formed.

Thereafter, the SOG oxide film **39** is eliminated as shown in FIG. **4F**. In this case, the elimination of the SOG oxide film **39** is carried out by putting the entire construction in a solution containing buffered oxide etchant (BOE) solution and pure water mixed in the ratio of 100:1 in a container.

Thereafter, as shown in FIG. **4G**, a dielectric film **41** and an upper electrode **42** is formed in serial order throughout the entire exposed upper surface of the resultant construction. In this case, the dielectric film **41** may be formed by using BST or PZT having high dielectric constant in a selective manner.

As described above, in the method for fabricating a capacitor of a semiconductor device according to the first embodiment of the present invention, when impurities are doped, the SOG film prevents damage to the  $\text{RuO}_2$  film, which serves as a storage electrode and degradation thereof due to the succeeding high-temperature process, so that the leakage current characteristic of the  $\text{RuO}_2$  film is improved.

Furthermore, in the method for fabricating a capacitor of a semiconductor device according to the second embodiment of the present invention, the upper electrode is formed by a laminated construction of tungsten silicide film/titanium nitride film/poly crystalline film on a dielectric film, so that the film qualities of the dielectric film and the upper electrode are prevented from being degraded.

Moreover, in the method for fabricating a capacitor of a semiconductor device according to the third embodiment of the present invention, since a stable ruthenium oxide film is formed between the lower electrode and the dielectric film, the density of the leaking current in the semiconductor device is reduced and thereby, the operational characteristic of the semiconductor device is improved.

Therefore, the method of the present invention improves reliability of a semiconductor device and further enables the high integration of the semiconductor device.

The present invention has been described in an illustrative manner, and it is to be clearly understood that the terminology used is intended to be in the nature of description rather than limitation.

Many modifications and variations of the present invention are possible in light of the above teachings. Therefore, it is to be understood that within the scope of the appended claims, the invention may be used in ways other than those specifically described.

What is claimed is:

1. A method for fabricating a capacitor of a semiconductor device, the method comprising the steps of:

preparing a semiconductor substrate;

forming an insulating layer on said semiconductor substrate;

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forming a contact hole which exposes said semiconductor substrate, by selectively eliminating said lower insulating layer;

forming a plug in said contact hole;

forming a first titanium nitride film on said plug and said lower insulating layer;

forming a ruthenium oxide film on said first titanium nitride film;

etching selectively said ruthenium oxide film and said first titanium nitride film;

forming a dielectric film having a high specific dielectric constant, on an exposed surface of said ruthenium oxide film, said first titanium nitride film, and said lower insulating layer;

forming a tungsten silicide film, a second titanium nitride film, and a polycrystalline silicon film on said dielectric film in serial order.

2. The method as claimed in claim 1, wherein said ruthenium oxide film is formed to have a thickness between

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2000 Å and 5000 Å in a low pressure chemical vapor deposition reactor under a temperature between 25° C. and 500° C.

3. The method as claimed in claim 1, wherein said step of etching selectively said ruthenium oxide film and said first titanium nitride film is carried out by means of Cl<sub>2</sub>/O<sub>2</sub> in a reactive ion etching reactor.

4. The method as claimed in claim 1, wherein said tungsten silicide film is formed in a low pressure chemical vapor deposition reactor under a temperature between 300° C. and 700° C.

5. The method as claimed in claim 1, wherein said dielectric film, having the high specific dielectric constant, is formed by means of Ba<sub>0.5</sub>Sr<sub>0.5</sub>TiO<sub>3</sub>.

6. The method as claimed in claim 1, wherein said dielectric film, having a high specific dielectric constant, is formed by means of lead zirconate titanate.

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